SCHOOL SCIENCE

Vol. 5 No. 1

March

In This Issue

Radio Telescope at Dwingeloo Holland

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

SCHOOL SCIENCE QUARTERLY

Vol. 5 No. 1

MARCH 1967

8|177

CONTENTS

Annual
Rs. 8.00

Per copy
Rs. 2.00

INSTRUCTIONS TO AUTHORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper and sent to the Editor, School Science, Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of School Science will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Please do not underline the headings.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article wherever possible. Each reference should contain the name of the author (with initials), the *year of* publication, the subject title of the publication, the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, *e.g.*, (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, *e.g.*, Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post card size, and should be sent properly packed so as to avoid damage in transit

SCHOOL SCIENCE QUARTERLY

Vol. 5 No. 2

JUNE 1967

CONTENTS

Annual
Rs. 8.00

Per copy
Rs. 2.00

INSTRUCTIONS TO CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper and sent to the Editor, School Science, Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of School Science will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Please do not underline the headings.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article wherever possible. Each reference should contain the name of the author (with initials), the year of publication, the subject title of the publication, the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, *e.g.* (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, *e.g.*, Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post card size, and should be sent properly packed so as to avoid damage in transit.

Published for the NCERT by P N. Natu, Secretary, 16 Ring Road, New Delhi 1, and Printed at the Indraprastha Press (CBT), Nehru House, New Delhi.

SCHOOL SCIENCE QUARTERLY

Vol. 5 No. 3

SEPTEMBER 1967

CONTENTS

Annual
Rs. 8.00

Per copy
Rs. 2.00

INSTRUCTIONS TO CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodolgy. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts in duplicate, including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced, on paper of uniform size and sent to the Editor, **School Science,** Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi 16. An article may not normally exceed ten typed pages.

The articles sent for publication should be exclusive to this journal Digests of previously published articles modified to suit the scope and purpose of **School Science** will be accepted. In such cases the name of the journal in which the original article appeared must be stated.

Headings should not be underlined.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article wherever possible. Each reference should contain the name of the author (with initials), the title of the publication, the place of publication, the name of the publisher, the year of publication the volume and page numbers

In the text, the reference should be indicated in brackets, by giving the author's name followed by the year of publication, e.g., (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, e.g, Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be done with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post-card size, and should be sent properly packed so as to avoid damage in transit.

Published for the NCERT by P. N. Natu, Secretary, 16 Ring Road, New Delhi 1 and Printed at the Indraprastha Press (CBT), Nehru House, New Delhi 1.

SCHOOL SCIENCE QUARTERLY

Vol. 5 No. 4

DECEMBER 1967

CONTENTS

Annual
Rs. 8.00

Per copy
Rs. 2.00

INSTRUCTIONS TO CONTRIBUTORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts, including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper, and sent to the Editor, **School Science**, Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi 16. Each article may not normally exceed 10 typed pages.

The articles sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of **School Science** will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Headings should not be underlined.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article, wherever possible. Each reference should contain the name of the author (with initials), the title of the publication, the name of the publisher, the place of publication; the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, e.g., (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, e.g., Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post-card size, and should be sent properly packed so as to avoid damage in transit.

Published for the NCERT by P N. Natu, Secretary, 16 Ring Road, New Delhi 1, and Printed at the Indraprastha Press (CBT), Nehru House, New Delhi.

Reorganization of Practical Training in Physics-I

B. Sharan

Indian Institute of Technology, New Delhi

IN the present age of technological advancement and keen competition scientific education is a must for our very existence. In any system of science education practical training assumes great importance. One hopes to find in the 'scientific citizens' of the future, dependable, careful and conscientious workers who are not perplexed by any new experimental situation, who have developed enough confidence to meet any challenge and offer a solution. Therefore, these 'scientific citizens' should clearly understand the principles of important experimental methods, the design of basic apparatus, the planning of experimental procedures and the significance of the final results. In short, the aim is to train not laboratory technicians but future research scientists.

For the subject to be interesting we must excite the curiosity of students. Their curiosity is aroused by proper questions which are challenging, which shatter their belief that they know everything, *e.g.*, 'How did people in the olden days subdivide charges for testing Coulomb's Law of Electrostatics?' This question shows up the difficulty which earlier scientists must have faced to test the Coulomb's law.

One should be clear about the aims and objects of an experiment. If one asks the question why a particular set of experiments has been chosen, invariably the answer would be that they satisfy the needs of the syllabus, and cover the major topics, *viz.*, optics, sound, heat, etc This random selection of experiments becomes monotonous. Are these experiments performed only because they have to be done?

Another drawback in the system prevalent in most of the institutions is that an experimenter goes to the laboratory with an instruction sheet of *Do's and Dont's* and performs the experiments mechanically. Most of the books on practical physics give the following type of instructions:

1. In a Young's modulus experiment, take the readings when the load is increasing and also when it is decreasing.
2. Take the mean of the observations in the above experiment in a particular way.
3. In a specific heat experiment choose a calorimeter of the given size.
4. Plot the graph in a given way, *e.g.*, voltage-current characteristics of a discharge tube.
5. Take a capillary tube about 8 cm. long for the surface tension experiment.
6. In the determination of the

relative density of sand fill one-third of the R.D. bottle with sand, etc.

In all these instructions, how we arrive at these absolute standards or why it should be done that way, remain unanswered. This type of training fails to impress the logical development of the subject, completely kills one's interest and dampens curiosity.

Practical training should, therefore, aim at waking the power of thinking and bringing up the creative faculty in man. A definite line of thought should run through all the experiments. They should not be merely a random selection from books on practical physics, chosen to meet the demands of a syllabus. Each scientific experiment should have a definite object. They are to be arranged in a series to reveal as clearly as possible some regularity in the behaviour of objects—a so-called natural law. Experiments are performed to test the validity of an intuitive explanation (prediction, hypothesis, theory or law) for an observation (a natural phenomenon) which it may confirm, reject or modify.

The experiment may be classified as exploratory, crucial, decisive, informative and academic, according to its nature. The systematic study of the natural phenomena like expansion of bodies on heating or stretching, and production of heat by friction has culminated in the discovery of the coefficient of thermal expansion, Young's modulus and Joule's law respectively. Becquerel's experiments on uranium compounds which resulted in the discovery of radioactivity were exploratory in nature. The crucial Michelson Morley experiment has confirmed the constancy of the velocity of light (one of the postulates of Einstein's theory of relativity), refuted the ether-drag theory and modified Newton's concept of relative velocity. The decisive experiment of Wilson established the extra-terrestrial nature of the cosmic rays. Rutherford's lamb shift experiment (informative) has shown the limited validity of Dirac's theory of atomic structure. The determination of the fundamental constants like the velocity of light, electronic charge, and Planck's constant, belong to the academic type

An experiment is a logical inquiry about any observation. It begins with a question such as why the leaves are green, the sky blue, or the walls white. As a result of enormous work in the past, systematic techniques for investigations have been developed and one must adopt them for quick gains.

Every experiment involves the measurement of certain number of observables (quantities). Some of these are more important and need finer measurements than others. The students must know it, and plan their experiments for optimum results. The unattainability of ideals (the absolute numerical values) and absence of necessary theoretical background is often discouraging, but it should not prevent us from doing work.

A good experimentalist is curious and active. He is keen on observation,

prompt in seeking an explanation, good in planning and experimental verification (may be qualitative or quantitative), critical in evaluation of his results, conscious of the shortcomings and inconsistencies. A keen observer will describe the phenomenon of double refraction in calcite in this way· 'on refraction through the cleavage plane of a rhombohedral crystal of calcite, the incident ray breaks up into an ordinary and an extraordinary ray; as the crystal is rotated about its normal axis the former maintains its position while the latter rotates such that the line joining the points of emergence of the extraordinary and the ordinary ray is always along the shorter diagonal of the crystal.' An ordinary observer will miss these portions. In other words keenness results in a complete and accurate description of a phenomenon with its distinguishing features.

The planning of practicals should aim at sustained curiosity and intellectual contentment. The planning of experiments must aim at developing initiative, interest and self confidence, exactitude, power of thinking, power of analysis, creative faculty, and sustained curiosity.

To sustain curiosity we begin with the following group of practical techniques:

(i) principles of measurement,

(ii) measuring instruments,

(iii) statistical methods,

(iv) choosing the optimum conditions,

(v) graphical methods, etc.

An independent study of the above mentioned topics may appear taxing and time-consuming to a student. These topics are therefore, usually left out. So long as the pointer of a meter is showing deflection, it does not worry a student. It becomes a worry when the persons take up responsible positions and are faced with the break-down of meters, measuring equipments and other similar realities of life. Thus, to increase the utility of practicals it is suggested that there should be:

1. lectures on practicals, followed by,
2. exercises on practicals.

The purpose of the first is to emphasize the continuity of thought and maintain curiosity, and that of the second is to hammer out principles by giving enough practice. It might be argued that practicals may be discussed at appropriate places during the theory periods. Here, it must be appreciated that theory has a different chain of thoughts, at times we may be discussing things on axiomatic foundations without bringing in any practicals; any discussion on practical aspects at such a stage will be like turning a sharp corner at a great speed producing knots in understanding.

The time for lectures and exercises on practicals can be provided by reducing some of the hours allocated to the practicals. A cut of 10 per cent has been suggested by some (Arregor 1964). An argument may be advanced against curtailing the number of practical

hours as it will reduce the number of experiments performed in a term. But these two points may be put forward in favour of curtailment. Firstly, it is better to do a little with good understanding than to do a lot without it. Secondly, there are many experiments which involve the same principle e.g. focal length of a lens by various methods (repetitive type) and many, which require less time for completion than given for them. Instead of keeping several experiments of the same type, it is better to have only one or two of the best kind. This will reduce the total number of experiments, and will save time for lectures on practicals and exercises

The idea of lectures on practicals and exercises is gaining momentum in Britain and Prof. Braddick (1963) has tried it with considerable success.

REFERENCES

Arregor, E 1964. Transition from School to University, **Bull. Inst. Phys. and phys. Soc.** 15 213-221

Braddick, H J.J 1963. The Physics of the Experimental Method Chapman and Hall Ltd, London, xi (Author's preface)

Chambers, R.G 1933 **Bull. Inst. Phys. and phys. Soc.** 14

Agriculture and the Artificial Transmutation of the Gene

M. S. Swaminathan

Indian Agricultural Research Institute, New Delhi

GREGOR Mendel, whose laws of heredity propounded in 1865 gave birth to the science of genetics during the present century, could carry out his studies in garden peas only because of the existence of the same gene in alternative forms of expression (known as alleles). The Dutch scientist, Hugo de Vries, showed that new alleles of a gene arise by mutations or permanent hereditary changes, and that mutations combined with the process of recombination of genes could lead to an unlimited degree of elaboration of hereditary characteristics. As a broad generalization, evolution can be pictured as a process of 'muddling through' of microbes into men as a result of recombination and selection operating upon blind (unpredictable) mutations. Simple organisms such as bacteria and viruses, with a new generation every 10 or 20 minutes and with enormous populations consisting of billions of individuals could well adjust to the vagaries of the environment by mutation alone. Due to the low frequency of spontaneous mutation, evolutionary progress in more complex organisms would result in a blind alley if it were entirely dependent on the occurrence by chance of mutations of the right type. The higher organisms have hence relied heavily on the exchange of genetic information with each other, a process popularly known as sex! No wonder then that Hugo de Vries wished very much that man could find a way of artificially altering the gene, thereby gaining control over the most powerful of the evolutionary mechanisms.

Fig. 1. Induction of awning in the wheat variety N.P. 799 which is awnless: left, ear head of N.P. 799; right, ear head of N.P. 836, an awned mutant of N.P. 799.

Reprinted from THE TIMES SCIENCE REVIEW July 5, 1965 with the kind permission of the Editor

The dream of Hugo de Vries was realized in 1927 when H. J. Muller in the United States showed that the sluggish natural mutation rate can be artificially accelerated by exposing living organisms to X-rays. In 1940, C. Auerbach and J. M. Robson of Edinburgh discovered that chemicals like mustard gas can also be used as mutagenic agents (this information was classified as secret during the second World War and published only at the end of the war). These discoveries raised new hopes in the hearts of the practical breeders who had until then been compelled to remain content with the mere making of recombinations of the material already at hand,

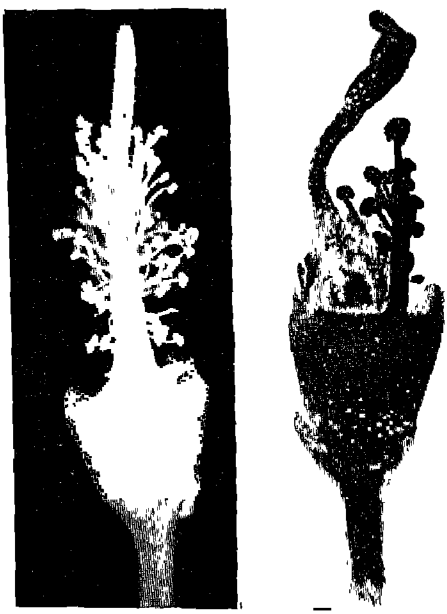


Fig 2. Induced flower variation in cotton **(Gossypium hirsutam): left,** normal condition where anther column surrounds the style; **right,** mutant where the anther column is separate from the style and stigma.

providentially supplemented, on rare and isolated occasions by an unexpected mutational windfall. A few examples of the role of spontaneous mutations in transforming a wild into a cultivated plant would be appropriate to give an idea of their impact on agriculture.

The possession of efficient mechanisms for self-propagation and self-protection is an essential requisite for the survival of a species in nature. Most of the wild relatives of cultivated cereals like wheat and rice have hence very tough glumes covering the grains and also very brittle attachment of the individual flowers to the inflorescence. As a result, it is difficult to thresh the seeds and collect them togeher. A mutation conferring easy threshing and a tough rachis was hence picked up when it occurred, by the early agriculturists. Similarly, in cotton the wild relatives do not possess the lint hairs essential for making cloth and a mutation which led to the origin of lint hairs, had obviously been isolated and preserved. In tobacco, all the wild relatives of the cultivated species have an enzyme which converts nicotine into nornicotine. If such a conversion takes place, there will be no nicotine in the mature leaves. A mutation which suppresses the action of this convertor enzyme has therefore been picked up by man and stabilized in our present-day varieties. The sweet lupin completely devoid of poisonous alkaloids developed in Germany 30 years ago represents a recent example of a spontaneous mutation capable of changing the agricultural history of the plant. In vegetatively propagated plants like

fruit trees, ornamental shrubs, potatoes and pineapples, the isolation of spontaneously occurring mutations has been a very important method of breeding.

Viewed in the above context, the enthusiasm of breeders for the artificial induction of mutations is understandable. Nearly 40 years of work in this field, however, has not fulfilled the early hopes, and the practical exploitation of the new variability created by treatments with mutagens—physical or chemical—has suffered from two major handicaps. First, most of the induced mutants being lethal or sub-lethal are useless from a practical standpoint. Secondly, nearly all of them are the same as are found in nature. Painstaking research in Sweden, Germany, the United States, Britain, India and other countries has, however, revealed that mutation breeding, when employed as a tool for solving a well defined problem, may prove to be very effective. Also, coincident with the growth of basic knowledge on the enhancement of mutation rate and the widening of the mutation spectrum, the effectiveness and utility of the mutation breeding technique have increased. This is already clear from the striking successes achieved in increasing many times the yield of the antibiotic principle in the organisms giving rise to penicillin, streptomycin, etc. In these organisms, the generation time is short, the screening procedures are very efficient and enormous populations can be conveniently handled. As a result, even a rare beneficial mutation can be picked up easily. The multicellular structure of higher organisms introduced many complication in the recovery of the mutations induced by different treatments, but recent work has shown that given a good understanding of the morphological, developmental and genetic architecture of a plant, much progress can be made in the practical exploitation of this technique. I shall cite in this article a few examples from the work of my colleagues and myself at the Indian Agricultural Research Institute on bread, wheat, and cotton to illustrate this. For convenience, I shall group them in four categories.

SPECIFIC DESIRABLE CHANGES

The wheat plant in the wild state has well developed bristles or awns on the flowers, as a protection mechanism. The European farmer has, however, selected naturally occurring mutations suppressing awn development, to facilitate easy threshing. In India, on the other hand, farmers prefer awned wheats as they are less prone to be damaged by birds. Many of the wheat varieties bred in India in recent years have the gene for awnlessness from European or North American varieties which have been used in crosses as donors of genes for rust resistance. By subjecting these improved awnless varieties to treatments with X-rays and gamma rays, mutants with well developed awns could be easily developed. The great merit of this procedure is that one desirable change can be brought about without in any way upsetting the adaptive and productive characteristics of the parent variety. Studies in N.P. 836, an awned mutant of the earlier variety N.P. 799, have shown that the introduction of awns in an awnless

variety helps to increase yield by about 10 per cent particularly in dry areas (Figure 1). Awns contain chlorophyll and they hence add to the photosynthetic surface. Consequently, the grain weight tends to be higher in the mutant, as compared to the parent strain and this difference has a striking effect on yields in dry areas, where the number of effective tillers per plant is only one or two.

Fig. 3. Ears of some induced mutants in **Triticium aestivum** resembling other species; left to right **Aestivum**-type (control); **Compactoid-type**; **Sphaerococcum**-type; **Turgidum**-type; **Speltoid**-type; **Vavilovoid**-type.

A mutation for grain colour produced this year by a combination of ultra-violet and gamma ray treatments in the dwarf wheat varieties, Sonora 63 and Sonora 64, developed in Mexico is another example of an induced specific desirable change. These dwarf varieties have the genes for short height, first isolated in the Norin wheats of Japan about 10 years ago. The transfer of the dwarfing genes (three distinct ones have been so far identified) to commercial wheat varieties has ushered in a new era in wheat yields. The variety Gaines bred in North America by incorporating the Norin dwarfing gene holds the world record for wheat production, having yielded nearly 10,000 lb. per acre in a 25 acre plot. The wheat varieties developed in Mexico under a cooperative programme of the Rockefeller Foundation and the Mexican Ministry of Agriculture have helped to treble the average yield of wheat in that country within a decade. Mexican dwarf wheats like Sonora 63 and Sonora 64 were hence introduced into India in 1963. During the past two seasons in fields fertilized with over 100 lb. of nitrogen these wheats have given yields of the order of 5,000 to 6,000 lb. per acre. With the previous varieties yields higher than 4,000 lb. per acre were seldom possible owing to the occurrence of severe lodging under conditions of high soil fertility and frequent irrigation. Though the morphological frame of the Mexican dwarf wheats proved ideal for intensive agriculture, they had red grains and hence gave dark chapatis (unleavened bread, which is the form in which wheat is mostly consumed in India). The farmer and the consumer prefer amber coloured wheat grains and hence these dwarf wheats were subjected to treatments with radiations and chemical mutagens. In the progenies of plants treated with ultra-violet and gamma rays, mutants with amber grains, which had all the other characteristics of the parent strains, were isolated and these can be appropriately regarded as the most precious atomic babies of 1965, so far as India is concerned.

Making Cotton Resistant to Jassids

One of the major needs of India is more extensive cultivation of cotton varieties with a long staple length. Many long staple varieties introduced from other

countries become severely infested with insects, particularly jassids.

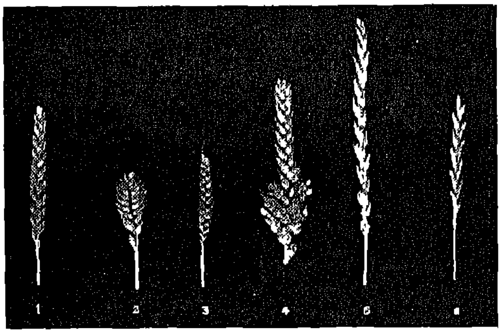


Fig. 4 Branched wheats developed by irradiation The extreme left is the ear of the parent variety and the others show varying extents of branching produced artificially.

Since dense hairness confers protection against jassids, Mescilla Acala, a variety highly susceptible to jassid attack, was irradiated with X-rays and in the progenies of the treated plants, mutants with a high degree of resistance to jassids were picked up. These mutants have all the other properties of the parent variety and have hence made the cultivation of this strain possible. Figure 2 shows a cotton mutant.

Quantitative Characteristics

Characteristics like yield, and maturity period, are governed by many genes and are referred to as quantitative or polygenic characters. The work done at New Delhi with many wheat varieties has shown that it would now be possible to plan experiments on the creation of new polygenic variability with a greater degree of anticipation of the end results. In general, our findings agree with those of some Australian workers in showing that in their direction, polygenic mutations follow a path opposite to that of the previous selection history for the character concerned. Thus, in late varieties early mutants occur more readily and *vice versa*. In varieties with a few tillers higher tillering types occur, while in varieties characterized by profuse tillering, mostly mutants with a reduced tiller number occur. If therefore a very early variety is desired for a particular region, it would be advisable to subject very late varieties to treatment with mutagens, rather than start with mid-early or early ones. Utilizing this principle, the tillering capacity of N.P. 876, a variety with short plan stature and good grain quality but poor tillering ability has been improved from an average number of six tillers per plant in the parent to over eight in the mutant.

Transmutation of Species

All the allied species of bread wheat, Triticum aestivum, have yeen synthesized from a single variety in New Delhi. The sub-species created artificially include what are known botanically as *compactum*, *sphaerococcum*, *spelta*, *macha* and *vavilovi* (Figure 3). A similar transmutation of species has also been accomplished in the emmer wheat series, to which the macaroni wheat, *T. durum*, belongs.

The origin of new species or subspecies through single gene mutations suggests that although the evolutionary scale is usually traversed only by minute steps, occasionally jumps of larger quanta can take place. While most of these mutants are largely of theoretical interest, a mutant in the bread variety

N.P. 797 obtained in treatments with radioactive sulphur (S^{35}) having the ability of adventitious branching recorded in nature only in the 'Egyptian Miracle Wheat' (T. turgidum var. mirabile) is of great practical interest. When it was first isolated this mutant had much sterility and also a weak expression of the branching character. By selection during the past five years, plants with well branched ears and good fertility have been developed (Figure 4). These plants produce nearly twice as many grains per acre as the parent variety. Fortunately they have also an associated dwarfing habit and may enable us to raise Sorghum-like wheat varieties.

Changes Not Found in Nature

Examples of the artificial creation of genes not found in a world collection of varieties exist in plants like barley and snapdragon, but they are very few This is to be expected since all genes mutate spontaneously also and any mutation which has selection value would have tended to get preserved. However, when the techniques of altering the gene become more refined, altogether new patterns of morphology and physiology could be aimed at. For example, in cotton varieties treated with X-rays, a type of rearrangement of flower structure never found in nature occurs. In the mutant flower, the anther column is separated from the style and stigma. If such a radical reorganization of the flower can be achieved, commercial production of hybrid cotton seed would become feasible, since crosses can be made easily by cutting off the anther column. So far, it has not been possible to stabilize this change; however, the experiments could never have been visualized and initiated but for the indication provided by the radiation treatment.

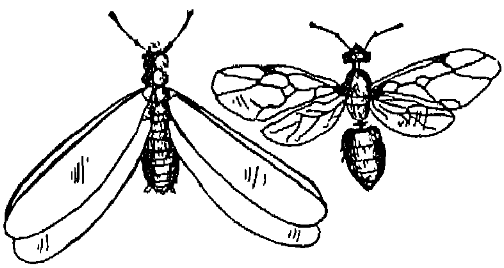
The above few examples from work on plants at one place would be sufficient to indicate what a potent tool the geneticist and plant breeder have today for reconstructing and accelerating evolutionary progress It is as yet not quite possible to induce a specific mutation at will, but the possibility of getting some types of mutations are better with some mutagens than with the others. For example, a particular type of sphaerococcoid mutant in wheat (resembling the naturally occurring species T. *sphaerococcum*) always occurs in varieties treated with the chemical mutagen, ethyl-methane-sulphonate, although it is extremely rare in radiation treatments. The use of chemical mutagens in combination with radiations is opening up new vistas in mutation breeding and it can be confidently hoped that before long such research will help to strike fresh paths in agriculture.

Social Insects - III White Ants

P. Kachroo

Indian Council of Agricultural Research, New Delhi

TERMITES or 'white ants' live together in communities They are of exceptional interest due to their complex organization and their social life, which parallel in a number of ways that of ants. They occur in the tropics as well as in most warm temperate lands. Normally, termites are pale-coloured and soft-bodied, with a delicate thin integument. Unlike true ants, they do not possess any constriction or 'waist' (the region where the abdomen unites with the thorax). The vast majority of the members of a colony are totally wingless. Unlike other social insects, there is no larval and pupal stage, thus, their metamorphosis is of a very slight character.



Termites are of great economic importance since nearly all of them feed on cellulose, which they obtain by injuring or destroying trees, shrubs, field crops and the woodwork of buildings. This destructive action causes immense loss to man, especially in the tropics.

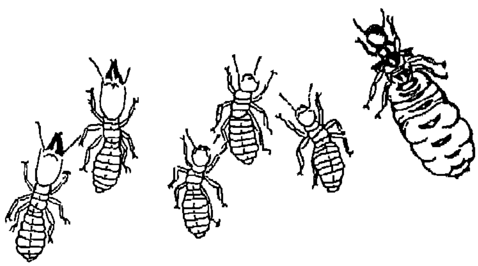
Termitaria

Termites live in the soil in very large numbers, more so in the tropics. Their nests are called *termitaria* These are of many kinds. Some of them do not construct true nests. They feed upon wood, making a series of hollow galleries in logs, decaying trees, or in fine timber. Some kinds burrow in the ground, constructing interconnected tunnels. Some of these appear as mounds above the surface. In Australia and Africa, they build huge nests of great durability by cementing together earthen particles by means of saliva or with faecal matter. On drying, this material becomes as hard as cement, and provides great protection against most vertebrate animals. The most remarkable termitaria are the lofty steeple-like structures constructed by the types abounding in northern Australia. These are as high as seven metres and about four metres in diameter at the base. Inside, there are numerous irregular chambers and passages, and in the deeper recesses the brood is reared, and the royal cell is also located here. Another Australian type has its nests about four metres tall: termitaria being flattened from side to side in a manner that results in the broad faces being directed east and west with the narrow ends north and south. In some parts of the world huge termitaria are congregated into 'villages' and present an interesting though depressing sight. Some termites construct carton-nests of masticated wood, oval or

rounded in shape, and about the size of a football or larger, up on trees. Some termites construct earth-like passages upon the surfaces of buildings or trees, to avoid exposure while in search of food. In the tropics these channels cover considerable distances to and from their nests and provide fairly constant conditions of humidity.

Life History

Termites comprise both male and female individuals. There are five principal castes, three reproductive and two sterile. The reproductive castes are, (i) normal-winged males and females or the true kings and queens, (ii) neoteric kings and queens and, (iii) wingless kings and queens. The sterile castes are wingless. They are workers and soldiers.



During the rainy season, the normal winged royal forms leave the nest in large numbers. After a brief flight, they alight on the ground and shed their wings. Many of them are eaten by birds, lizards, etc. The few that survive found new colonies. To begin with each colony has a royal pair. They soon dig a small cavity in the ground. Here the queen lays eggs and the royal pair feed and tend their offspring, until enough workers have been reared. The workers start further digging activities. More workers are reared by now and after some time the new colony hums with life. The queens lay at least a million eggs each year and they live for a number of years. In the new generation there are also wingless royal forms and on the death or destruction of the original queen they develop into the new functional royal females. The workers perform almost all the community functions. They tend the eggs and the young forms of the royalties. They forage for food, often at a distance from the nest, and remain busy in construction, repair and upkeep of the colony. They also excavate the galleries and tunnels. The gnawing propensity is very great and destructive. They are man's worst enemies.

Upon the soldiers, falls the responsibility of defending the colony. They use their strong jaws in forcing out the insect enemies. Some of them with large jaws remain assembled and stand guard at the surface of the nest to prevent injury or break in its walls. They are very effective defenders due to the presence of a greatly developed frontal gland, which discharges a pungent secretion on even slight attack of ants and other insect enemies.

Feeding

Termites have strange feeding habits. Dead parts of plants form the main diet, but they also feed upon, rather indiscriminately, faecal matter ejected by their fellows, and even their dead members.

The young and the royal forms are fed upon best feed and saliva of workers. They also lick glandular products exuded from the skin of other members of the colony. The queen produces the maximum quantity of exudation and the workers are seen licking her in large numbers. It is interesting that unless the eggs are licked and tended by the workers they fail to hatch.

Some types of termites are quite adventurist, and conduct foraging expeditions. The food thus collected is stored within the nest for future use. Some termites cultivate fungus-beds in special chambers of the nest. These provide vegetable matter and serve as nurseries for the brood.

Chemical Fertilizers

Christopher J. Pratt

IT is clear that the present rate of increase in the human population is alarmingly high.

Three centuries ago the number of people in the world was probably about 500 million; now it is more than three billion. If the current rate of increase holds, it will be six billion by the end of the century and milennium.

In some underdeveloped areas, where the rate is highest, the Malthusian prediction that population would eventually outrun food supplies seems close to reality.

Clearly, mankind faces a formidable problem in making certain that future populations have enough to eat. Doubtless a partial solution lies in improved technology, which has already done so much to keep the food supply abreast of population, and in the spread of existing technology from the developed to the underdeveloped countries.

It should also be possible to bring some new areas under cultivation or grazing, but the opportunities in that direction appear to be limited. Even though only about seven per cent of the earth's land area is used for crop production in any one year, most of the unused land is too dry, or too cold, or otherwise unsuitable for agriculture.

Neither extensive clearing of forests nor large-scale cultivation of tropical lands offers as much promise. Much of the soil in such regions is lateritic and turns hard as the result of oxidizing when it is put to the plough.

With huge amounts of capital and carefully planned projects it would be possible to create much new cropland by vast undertakings of irrigation, drainage, and other kinds of reclamation. But even if such projects were launched, however, they would take decades to complete. It seems more feasible to look to shorter-range ventures, particularly in those developing areas where famine is an imminent threat.

Of all the short-range factors capable of increasing agricultural production readily — factors including pesticides, improved plant varieties, and mechanization — the largest yields and most substantial returns on invested capital come from Chemical Fertilizers.

The application of these substances to under-fertilized soils can have dramatic results. In a typical situation the ratio of the extra weight of grain to weight of nutrients applied can be as high as 10 to 1. To put it another way, an investment of this kind alone can quickly produce increases in crop yields of 100 to 200 per cent.........But the Requirements are Vast.

Reprinted from SCIENTIFIC AMERICAN June 1965 with the kind permission of the Editor.

Today more than thirty million tons of the so-called primary nutrients—nitrogen, phosphorus, and potassium—are annually supplied to world agriculture by chemical fertilizers. This amount is hardly adequate, for reasons I shall discuss. Moreover crop yields diminish in proportion to the amount of fertilizer applied. Therefore, it can be estimated that a population of six billion in the year 2000 will require at least 120 million tons of primary nutrients (four times our present supply).

Fertilizer Requirements for India (in tonnes) for Food Grains and Oil Seeds

	Present Use	*1975 Requirements**	*Necessary Increase*
Nitrogen	284,000	5,251,000	19-fold
Phosphate	80,000	3,581,000	44 „
Potash	17,000	1,564,000	92 „

An increase of ninety million tons of nutrients for three billion more people means that sixty pounds of primary nutrients will be needed to help sustain each additional person for a year. This is equivalent to about one 100-pound bag of modern high-analysis chemical fertilizer.

Stated in such a way, the amount of effort required to supply the additional fertilizer may seem modest. Actually the expansion of capacity required is enormous; achieving it may well become a major preoccupation of technology. Fortunately, processes for manufacturing the needed substances are already well established on a large scale and are capable of rapid expansion, provided that enough capital is made available and the necessary priorities are given.

Considering all these factors, it is appropriate to review briefly the fertilizer situation: how plants utilize nutrients, how chemical fertilizers are manufactured, how they are best applied, and how the increasing demand for them can be met by chemical technology.

Major and Minor Plant Foods

A growing plant requires most or all of sixteen nutrients, nine in large amounts and seven in small. The former are sometimes called macronutrients, the latter micronutrients. Most plants obtain three of the macronutrients—carbon, hydrogen, and oxygen—from the air and all the other nutrients from the soil. (A few species, such as clover, are able to fill their nitrogen needs from the air.)

The primary soil macronutrients—nitrogen, phosphorus, and potassium—are the N, P, and K often seen on bags of fertilizer, they are also the substances represented by the set of three figures, such as 10-12-8, that normally designates the nutrient content of a fertilizer. Usually these figures respectively denote the percentage in the fertilizer of: (i) total nitrogen (N) (ii) of phosphorus pentoxide (P_2O_5, often called phosphoric acid or phosphate)

*Assuming: 1 a population of 609,000,000; 2. an increase in per capita caloric intake from 2,050 to 2,500; 3. a modest improvement in the protein component of average diets.

in a form available for use by plants; and (iii) of water-soluble potassium oxide (K_2O, usually called potash)

The three other soil macronutrients—calcium, magnesium, and sulphur—are often called secondary. Agricultural lime, limestone, and dolomite, which are used to correct soil acidity, also serve as sources of calcium and magnesium. Sulphur deficiencies can be remedied by certain commercial fertilizers. The seven micronutrients, which are sometimes added in traces to fertilizers providing one or more of the primary nutrients, are boron, copper, iron, manganese, zinc, molybdenum, and chlorine.

Digesting Plant Food

The growth of plants is a highly complicated process that is far from fully understood. For the purposes of this article it is enough to say that the usual path of mineral nutrients is from the soil into the root.

The actual transfer of nutrients from soil to root involves the movement of mineral ions. These ions are contained mostly in the soil water, but some of them are adsorbed on solid soil particles

It follows that nutrients must be in ionic form or capable of transformation to ionic form by soil processes if they are to be of any value to the plant. Hence it is not necessarily a lack of minerals in a soil that causes plants to show signs of nutrient deficiency; the problem can also be that the nutrients are not in a form readily available to the plant.

For example, it is quite possible for crops to starve in soils that are amply supplied with phosphorus and potassium if these nutrients are insoluble in water or plant juices. Essentially what the chemical fertilizer industry does, in addition to converting inert nitrogen from the air into soluble salts, is to employ processes to open the molecules containing the vital nutrients so that these molecules form soluble salts that plants can assimilate readily.

Soils' Voracious Appetites

One can best grasp the need for mineral nutrients in agriculture by taking account of the nutrients that are removed from the soil by cropping and grazing. A ton of wheat grain is equivalent to about forty pounds of nitrogen, eight pounds of phosphorus, and nine pounds of potassium. If the straw, husks, roots, and other agricultural wastes of such a crop are not returned to the soil, they represent additional large losses of nutrients.

A ton of fat cattle corresponds to a depletion of about fifty-four pounds of nitrogen, fifteen pounds of phosphorus, three pounds of potassium, and twenty-six pounds of calcium. Such rates of removal will quickly exhaust a typical soil unless the losses are made up by regular additions of suitable fertilizer.

Equivalent additions of fertilizer, however, are not really enough. There are other factors to be taken into account, and they explain why the present consumption of fertilizers is barely adequate. Nutrients are leached from soils by the flow of water; moreover, they are fixed

in forms not readily available to plants As a result of such losses, the proportion of soil nitrogen and phosphorus utilized by a crop is rarely more than seventy-five per cent. In some instances the utilization of phosphorus is as low as ten per cent.

Even allowing for losses, the increased crop value resulting from the proper application of fertilizer can be substantial. On a poor soil the gain can approach ten times the cost of the material applied. Where the soil is good and the crop yields are high the gain from fertilizing is more likely to be three to five times the cost of the fertilizer.

Because of this diminishing return there eventually comes a point at which the additional yield no longer justifies the cost of the corresponding extra fertilizer. There is also an agronomic reason for avoiding the over-application of fertilizer, ultimately a point can be reached at which the high concentration of nutrient salts in the soil can damage the plants.

Modern Fertilizer Production

Today a farmer can buy a wide variety of chemical fertilizers. If he wants only one nutrient, he can find a fertilizer that provides it, he can also find fertilizers that contain almost any combination of nitrogen, phosphorus, potassium, and the micronutrients.

The industry that produces them is enormous, having a worldwide output, according to a recent estimate by the Food and Agriculture Organization, of more than thirty-three million tons a year. I shall briefly describe the processes now involved in producing the primary nutrients

Nitrogen Sources (N)

Synthetic ammonia is firmly established as the principal source of nitrogen in fertilizer. Ammonia synthesis remains unchanged in principle from the technique developed by Harper and Bosch in Germany in 1910 Large-scale production often presents additional problems, however, because of the need to obtain huge supplies of pure gaseous nitrogen and hydrogen at low cost.

Pure nitrogen can be produced in quantity with relative ease by removing oxygen and other gases from air through liquefaction or combustion.

Hydrogen is another matter. Some early ammonia plants used hydrogen made by electrolysis, but the prohibitive cost led to a search for cheaper sources Methods for producing hydrogen from solid fuels, such as coal and lignite, were developed in Europe.

In the United States where natural gas is plentiful, the simpler catalytic reforming of methane has proved an ideal way of making hydrogen. More recently the catalytic re-forming of light petroleum fractions, such as naphtha with the aid of steam and the partial oxidation of heavy oil with oxygen, have been widely used in countries that lack natural gas.

Although there is a strong trend, particularly in the United States towards injecting ammonia directly into the soil in the form of anhydrous ammonia or

aqueous solutions, most agricultural ammonia is still converted into solid derivatives. Ammonium nitrate is a form popular among manufacturers, since the nitric acid needed to produce it is also made from ammonia.

Similarly, large amounts of urea are produced by combining ammonia with carbon dioxide derived from oxidation of the raw material used to produce the hydrogen. Ammonium sulphate is also made on a large scale by reacting ammonia with sulphuric acid.

In the Far East, substantial quantities of ammonium chloride are made from ammonia and salt or hydrochloric acid. Ammonium phosphates and nitrophosphates are additional fertilizers derived from ammonia.

A principal advantage of most solid forms of ammonia is the ease with which they can be transported and applied to the soil. The high nitrogen content of urea (46 per cent) and ammonium nitrate (33.5 per cent) make them particularly advantageous.

Phosphate Sources

Most phosphate fertilizers now come from mineral deposits, chiefly those in Florida, the western US, North Africa, and parts of the USSR. Although both igneous and sedimentary phosphate deposits exist, about 90 per cent of the world's fertilizer needs are supplied from the sedimentary sources because they are more plentiful than the igneous mineral and also easier to mine and process.

Few minerals are found more widely scattered. But the phosphate pellets are often found under several feet of sand, clay or leached ore that must be taken off by scrapers or draglines before the phosphate matrix can be removed.

In the extensive operations in Florida, the matrix is excavated, dropped into sumps, slurried with powerful jets of water, and then pumped to the processing plants. The material thus obtained may be only about fifteen per cent phosphate because of the large amounts of sand and clay in the matrix. Much of the sand and clay is removed by various processes to yield concentrates containing 30 to 36 per cent phosphate. These concentrates are then blended and dried before further processing or shipment.

Somewhat different methods are used in North Africa; where large tonnage of high-grade phosphate rocks are mined by underground methods. Often they are only crushed, screened, and dried before shipment.

Several types of fertilizers are made from the phosphate rock processed by the methods I have described. The simplest type consists of high-grade rock ground to particles less than one millimetre in size. This type is used directly on acid soils, which slowly attack the water-insoluble phosphate to make it available to plants.

Next in simplicity is superphosphate, made by mixing ground phosphate rock with sulphuric acid to form a slurry that quickly hardens in a curing pile. After several weeks the hardened superphosphate is excavated and pulverized;

often the powder is formed into granules.

The pulverized or granulated material is marketed either alone, as a phosphate fertilizer containing about 18 per cent water-soluble phosphorus pentoxide, or in conjunction with other fertilizer materials The various processing steps convert insoluble tricalcium phosphate to water-soluble monocalcium phosphate and gypsum.

Gypsum, however, is of little use in soil except when deficiencies in calcium or sulphur exist or when salinity is excessive. It also has a diluting effect on the phosphorus pentoxide content.

Therefore, it was a substantial advance when methods were devised for producing monocalcium phosphate without gypsum. The technique is to dissolve phosphate rock in a mixture of sulphuric and phosphoric acid to form gypsum and additional phosphoric acid, which can be separated by filtration.

Thereafter the gypsum is usually discarded; the phosphoric acid is concentrated and mixed with finely ground phosphate rock to form a slurry that soon hardens into a product known as triple superphosphate. Its content of water-soluble phosphorus pentoxide is about forty-eight per cent. Moreover, the product is cheaper to transport and to apply per unit of phosphorus pentoxide than ordinary superphosphate.

Substantial tonnages of phosphate fertilizers are also made by treating phosphate rock with nitric acid and ammonia to yield a range of materials that contain nitrogen as well as phosphorus Potash can be added to form high-analysis fertilizers with a content of primary nutrients as high as sixty per cent, as for example, in a 20-20-20 grade.

Another popular fertilizer is diammonium phosphate, which is made by neutralizing phosphoric acid with ammonia to yield a material containing about 20 per cent nitrogen and 50 per cent water-soluble phosphorus pentoxide. Potash can be added to this product to make another high-analysis mixture containing all the primary nutrients.

Potassium Sources (K)

Potassium exists in enormous quantities in the rocks and soils of the world. Often, however, it is in the form of insoluble minerals unsuitable for agriculture. Fortunately large deposits of soluble potassium chloride are available, mostly as sylvite and sylvinite or, in conjunction with magnesium, as carnallite and langbeinite. Such deposits are often mixed with sodium chloride in the form of halite, which is toxic to many crops and must be removed.

Extensive supplies of sylvite and carnallite were found first in Germany and later in France, the western U.S. and many other countries.

In the Canadian province of Saskatchewan huge quantities of sylvite and carnallite were more recently found at depths of 3,000 to 4,000 feet. Although these deposits are considerably deeper than U.S. and European potash sources, mining difficulties have now been overcome and the production of several

million tons annually of Canadian potash will be of great benefit to world agriculture.

Another Canadian development of growing importance is the large-scale production of potash by solution mining, which involves pumping water into the potash beds and bringing the resulting solution to the surface for evaporation and the recovery of potash in solid form.

Methods of Using Potassium

After solid potash minerals are mined, they are sometimes crushed and separated from their impurities by washing and froth-flotation, in which treatment with amine salts and air crushes the sylvite particles to float away from the unwanted substances. In other cases, potash is recovered by solution and crystallization. The relatively pure product is dried, treated with an amine anticaking agent, and sold for agricultural purposes as muriate of potash containing 60 to 62 per cent of potassium oxide.

Most potash is used in conjunction with nitrogen and phosphorus compounds. Potassium sulphate and potassium nitrate are also used to a limited extent in agricultural situations where the chloride ions of potash would be harmful, as they are to tobacco.

Detecting Major Soil Deficiencies

It is appropriate now to consider the role of nutrients in plant growth, together with some other factors that must be taken into account in the use of fertilizers. As anyone experienced in agronomy or gardening knows, it is wasteful and sometimes even harmful to broadcast fertilizer indiscriminately.

The grower must know the condition of his soil and treat it accordingly. In most cases he must apply the bulk of the treatment before sowing, because as a rule most of the nutrient needed by a plant is taken up in the early stages of its growth.

The correct nutrient balance is additionally important because a deficiency of any one plant food in the soil will reduce the effect of others, even if they are in over-supply.

A deficiency of nitrogen usually appears in plants as a yellowing of the leaves, accompanied by shrivelling that proceeds upward from the lower leaves. The principal effects of nitrogen on plants include accelerated growth and increased yield of leaf, fruit, and seed. Nitrogen also promotes the activity of soil bacteria.

Nitrate nitrogen is quickly available to root system, but it may, therefore, make the plants grow too rapidly. Moreover, nitrate is easily lost by leaching. Ammoniacal nitrogen, on the other hand, is immediately fixed in the soil by ion-exchange reactions and is released to the plants over a longer period than nitrate nitrogen.

For these reasons it is sometimes the practice to inject free ammonia in anhydrous or aqueous form a few inches below the surface of a moist soil. With many crops optimum results are

obtained by the proper combination of nitrate nitrogen and ammoniacal nitrogen in either solid or liquid form.

Phosphorus deficiency is often represented by purlish leaves and stems, slow growth and low yields. Phosphorus stimulates the germination of seedlings and encourages early root formation. Since these results are less evident than those induced by applications of nitrogen, many farmers, particularly in the Far East, use insufficient quantities of phosphate fertilizer.

Potassium deficiency can often be detected by a spotting or curling of lower leaves. Additional symptoms are weak stalks and stems, a condition that can cause heavy crop losses in strong winds and heavy rains. The application of potassium improves the yield of grain and seed, and it enhances the formation of starches, sugars, and plant oils. It also contributes to the plant's vigour and its resistance to frost and disease.

As for deficiencies of secondary nutrients, a lack of magnesium may cause a general loss of colour, weak stalks, and white bands across the leaves in corn and certain other plants. A calcium deficiency may give rise to the premature death of young leaves and poor formation of seed. An inadequate supply of sulphur frequently leads to pale leaves, stunted growth, and immature fruit.

Typical examples of micronutrient deficiency are near rot in vegetables and fruits as a result of a shortage of boron and stunted growth of vegetables and citrus plants resulting from insufficient manganese and molybdenum. Micronutrient deficiencies may be hard to rectify, because the balance between enough of a micronutrient and a toxic over-supply can be delicate.

An important consideration in the use of fertilizers is the acidity of the soil, which considerably influences the availability of many nutrients to the plant. To complicate matters, nitrogen fertilizers, such as ammonia, urea, ammonium nitrate, and other ammonia derivatives, can themselves raise the acidity of soils, by means of complex ion-exchange reactions. In most cases the acidity of a soil can be controlled by adding appropriate amounts of lime, ground limestone, or other forms of calcium carbonate.

Soil tilth, or structure, is also important. For example, the richer chernozem soils found in the middle of the North American continent and in the Ukraine are in many cases well supplied with organic humus and lime salts and need only regular supplies of plant nutrients to replace those removed by agriculture and leaching.

On the other hand, the padzol soils that cover the north-eastern U.S. most of Britain, and much of central Europe have been intensively leached by centuries of farming and exposure; they need not only liberal supplies of plant nutrients but also lime and organic humus.

Desert soils may be rich in certain minerals and yet lacking in available nutrients and in the organic matter usually necessary to retain moisture and

to provide good tilth. Such soils can be made productive, however, as has been amply demonstrated in Israel.

New Forms of Fertilizer

In spite of the many improvements made in chemical fertilizers during the past fifty years, several problems still confront the fertilizer industry. One major concern is achieving the controlled release of nutrients so that waste and also damage to young plants can be avoided.

Methods now being tested include the use of slowly decomposing inorganic materials such as magnesium ammonium phosphate and synthetic organic compounds such as formamide and oxamide.

Another technique being studied is the encapsulation of fertilizer particles with sulphur or plastic.

Investigators are also exploring the possibilities of producing chemical ferti-

TABLE

Substance	*Approximate Pound Per Acre*	*Supplied by*
Nitrogen	310	
Phosphorus	120 (Phosphate) 52 (Phosphorus)	1. 200 Pounds of 25-10-20 Fertilizer
Potassium	245 (Potash) 205 (Potassium)	
Calcium	58	Approximately 150 pounds of agricultural limestone.
Magnesium	50	Approximately 275 pounds of epsom salt or 550 pounds sulphate of potash magnesia.
Sulphur	33	33 pounds of sulphur
Iron	3	15 pounds of iron sulphate
Manganese	0.45	Approximately 1.3 pounds of manganese sulphate.
Boron	0.10	Approximately one pound borax.
Zinc	Trace	Small amount of zinc sulphate.
Copper	Trace	Small amount of copper sulphate or oxide.
Molybdenum	Trace	very small amount of sodium or ammonium molybdate.
Oxygen	10,200	Air
Carbon	7,800	Air
Water	3,225 to 4,175 Tons	29 to 36 inches of rain.

*Nutrients required to produce 150 bushels of corn are indicated. Most plants take all their nutrients from the soil except carbon, oxygen, and hydrogen, obtained from the air.

lizers in which a plant nutrient would be 'sequestered' in molecules of the chelate type. Chelation involves a tight molecular bonding that would protect the nutrient against rapid attack. In this way the desired plant food would be released slowly and in a prescribed manner by chemical reactions in the soil.

An ultimate possibility is the production of 'packaged' granules, each containing a seed and whatever substances are needed during the lifetime of the plant. They would be released in the proper amounts and sequence.

Chemical Ploughing

A new agricultural technique already in use on a small scale is chemical ploughing. Instead of turning stubble and cover crops into the ground mechanically, the farmer kills them by spraying them with the appropriate herbicides. Eventually the dead plant materials become sources of humus and plant nutrient. Any excess of herbicide is rendered harmless by the action of soil colloids. New seeds and fertilizers are drilled directly through the dead cover material, which also gives protection against erosion, frost, and drought.

Efforts are also under way to reduce the cost of transporting fertilizers and their raw materials. The approach here is to try to produce them in highly concentrated liquid or solid form. They are then appropriately diluted or combined at the point of use.

Perhaps the most vital work is the education of farmers—particularly farmers in the developing countries—in modern agricultural methods, including the use of chemical fertilizers.

In addition, the developing nations must establish low-cost credit plans so that impoverished farmers can buy adequate supplies of fertilizers.

Similarly, credit must be extended by the developed nations to the less developed ones on an even bigger scale than at present in order to help the less developed nations obtain the materials, equipment, and expert advice they need to build their own chemical fertilizer plants.

Until these steps are taken to spread modern agricultural technology, the developing nations will fall far short of the contribution they could make to the intensifying problem of producing enough food for the world's growing population.

Problem Solving in Mathematics-I

Truman Botts

University of Virginia, Charlottesville, Virginia

IT is by no means beating a dead horse to urge the importance of mathematics for problem solving, and especially problem solving in the schools, at every level from kindergarten on. Fortunately, there is nowadays a growing realization of the importance of mathematical problem solving, and a growing list of books and journals where good problems, at every level, can be found. I'm not talking about routine exercises in school books—'drill' problems—though it may be said in defence of these that problem which an adult finds routinely easy and dull may yet be both difficult and fascinating to a child. Today, even at the elementary school level there is an increasing body of non-routine challenging mathematical problems for those bright children some of whom will develop into the next generation's mathematicians and scientists. I'm thinking, for instance, of some of the 'braintwisters' in the School Mathematics Study Group's writings, and especially of the ingenious supplementary problems for 'fast' students devised for the SMSG primary and elementary school materials by Frank Sinden of Bell Telephone Laboratories.

At a more advanced level we may mention George Polya's recent book *Mathematical Discovery*, Volume I: *On Understanding, Learning, and Teaching Problem Solving* (Wiley, 1962), as well as his earlier, more sophisticated books *How to Solve It* (Princeton, 1945) and *Mathematics and Plausible Reasoning* (Princeton, 1954). The books of good problems accessible to high school students include the *Contest Problem Book* (No. 5 in the 'New Mathematical Library' produced under the monograph programme of SMSG) and the *Hungarian Problem Book* in two volumes (Nos. 11 and 12 in the 'New Mathematical Library'). Hugo Steinhaus' *One Hundred Problems in Elementary Mathematics* (Basic Books, 1964), translated from a Polish book of the year 1963, contains many fascinating problems (with answers) at the high school to college level. And at a higher, collegiate level we may mention the problem sections of the *American Mathematical Monthly* and *The Otto Dunkel Memorial Problem Book* edited by Howard Eves and E. P Starke and published in 1957 as a supplement to the *American Mathematical Monthly*. It contains a selection of 400 'best' problems from the *Monthly*'s problem sections during the period 1918 to 1950.

Reference may also be made to the problem section of the *Mathematics*

Reprinted from THE MATHEMATICS TEACHER, 58 (6), October 1965 with the kind permission of the Editor.

Magazine and to twenty-seventh and twenty-eighth yearbooks of the National Council of Teachers of Mathematics. In the twenty-seventh Yearbook, chapters 5, 12 and 14 bear on the general question of problem solving, while Julia Adkins' article on 'Unit Fractions' (chap. 15) is directly related to the arithmetic problems to be considered below. In the twenty-eighth yearbook, chapters 1, 14, 15, 16, and 17 have material on problem solving, and some excellent problems.

A Problem From Arithmetic

I should now like to consider an actual problem from one of these books (*Hungarian Problem Book*, Vol. II, p. 15, problem No. 2, for the year 1918). It begins as just a simple problem from arithmetic, but, like many good problems, it leads, as we shall see, to further problems. Right now I'd like to approach this problem 'naively', as much as any capable and intellectually curious but only moderately knowledgeable high school student might do. Then, in a second article, to be published next month, I'd like to give you some interesting historical highlights on the ideas to which this problem leads, carrying these through from ancient times right up into the year 1964.

Here is the problem from *Hungarian Problem Book*, Volume II:

The Problem: *Can you find three (different) positive integers the sum of whose reciprocals is an integer?*

Otherwise phrased, can you find three positive integers a, b, and c such that, say, $a < b < c$ and such that

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c}$$

is an integer?

A student can quickly find by 'trial and error' that $a=2$, $b=3$, $c=6$ will do, because

$$\frac{1}{2} + \frac{1}{3} + \frac{1}{6} = 1$$

an integer. So the bare question posed is easily answered. But an inquiring mind ought not to stop there: it would be reasonable to ask if there are any other solutions of this problem. We quickly see that there couldn't be very many; for if a, b, c are at all large, then the sum of their reciprocals will be too small even to add up to 1. In fact,

$$\frac{1}{3} + \frac{1}{4} + \frac{1}{5} < \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1$$

So we might suspect that 2, 3, 6 constitute the only solution to the problem. Can we prove this? That is, we are now conjecturing a theorem:

Theorem: *The only positive integers* a, b, and c such that $a < b < c$ and such that

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c}$$

is an integer are $a=2$, $b=3$, and $c=6$.

Let us think about how we might prove this theorem.

First, why must we have $a=2$? Could we have $a=1$? A moment's reflection shows that we could not. For then $b \geqq 2$ and $c \geqq 3$. But then

$$\frac{1}{b} \leqq \frac{1}{2} \text{ and } \frac{1}{c} \leqq \frac{1}{3},$$

$$1 < \frac{1}{1} + \frac{1}{b} + \frac{1}{c} \leqq 1 + \frac{1}{2} + \frac{1}{3}$$
$$= 1\frac{5}{6},$$

showing that

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c}$$

could *not* be an integer.

Could we have $a > 2$? No! For then $a \geqq 3$, $b \geqq 4$ and $c \geqq 5$, whence

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c} \leqq \frac{1}{3} + \frac{1}{4} + \frac{1}{5} < \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1$$

as noted before

Therefore we *must* have $a = 2$

Next, we must have $b=3$. For if $b \geqq 4$, then $c \geqq 5$, whence

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c} \leqq \frac{1}{2} + \frac{1}{4} + \frac{1}{5} < \frac{1}{2} + \frac{1}{4} + \frac{1}{4} = 1$$

Now we know $a = 2$ and $b = 3$, so $c \geqq 4$ Therefore

$$1 \leqq \frac{1}{2} + \frac{1}{3} + \frac{1}{c} \leqq \frac{1}{2} + \frac{1}{3} + \frac{1}{4}$$
$$= \frac{6}{12} + \frac{4}{12} + \frac{3}{12} = \frac{13}{12} = 1\frac{1}{12},$$

so that the only possible integer that

$$\frac{1}{2} + \frac{1}{3} + \frac{1}{c}$$

can be is 1. Hence $c=6$, and the proof is complete.

A Generalization

We have managed to express 1 as the sum of the reciprocals of three positive integers. This fact might suggest the following further problem:

Problem: *For which positive integers n can we express 1 as the sum of the reciprocals of n (different) positive integers?*

In trying to answer this question we might begin by using the fact that

$$1 = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$$

in the following way:

$$1 = \frac{1}{2} + \frac{1}{2}$$
$$= \frac{1}{2} + \frac{1}{2}\left(\frac{1}{2} + \frac{1}{3} + \frac{1}{6}\right)$$
$$= \frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{12}.$$

In this way we have expressed (arabic) 1=one as the sum of the reciprocals of four positive integers, namely, 2, 4, 6, and 12.

What we have done once we can do again:

$$1 = \frac{1}{2} + \frac{1}{2}$$
$$= \frac{1}{2} + \frac{1}{2}\left(\frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{12}\right)$$
$$= \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}$$

This expresses 1 as the sum of the reciprocals of the five positive integers 2, 4, 8, 12, and 24. It is clear that we can repeat this process further. In fact, if we write this last relation in the form

$$1 = \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \frac{1}{2^2.3} + \frac{1}{2^3.3},$$

it suggests the following theorem:

Theorem: *For every positive integer* n,

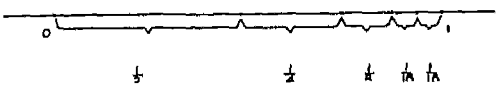
$$(3.1)\quad 1 = \frac{1}{2} + \frac{1}{2^2} + \dots + \frac{1}{2^n} + \frac{1}{2^{n-1}.3} + \frac{1}{2^n 3}$$

This theorem, if it is true, expresses 1 as the sum of the reciprocals of $n+2$ (different) positive integers, namely, 2, $2^2, \ldots, 2^n, 2^{n-1}.3$, and $2^n.3$

To see that the theorem is true, we might begin with the equation

$$(3.2)\quad 1=\left(\frac{1}{2}+\frac{1}{2^2}+\cdots+\frac{1}{2^n}\right)+\frac{1}{2^n},$$

which is almost obvious when we think of cutting a line segment of length 1 into halves successively on the right, as suggested for the case $n=4$ in the figure below



If we now re-write the last term in equation (3.2) as follows:

$$\begin{aligned}\frac{1}{2^n}&=\frac{1}{2^{n-1}}\cdot\frac{1}{2}\\&=\frac{1}{2^{n-1}}\cdot\left(\frac{1}{3}+\frac{1}{6}\right)\\&=\frac{1}{2^{n-1}.3}+\frac{1}{2^n.3},\end{aligned}$$

we obtain the desired equation (3.1).

A Different Generalization

Since the solution of the original problem expressed the particular positive integer 1 as a sum of reciprocals of positive integers, another more general problem that might suggest itself is this:

Problem: *For which positive integers m can we express m as a sum of the reciprocals of some number of positive integers, all different?*

There are undoubtedly several ways of getting started on this question. One way might be to begin by thinking of m as the sum of ones:

$$m=1+1+\ldots+1 \text{ (} m \text{ summands),}$$

We could express the first 1 as

$$\frac{1}{1}.$$

We could then express the second 1 as

$$(4.1)\qquad \frac{1}{2}+\frac{1}{3}+\frac{1}{6}.$$

Next, we might wonder, could we express the third 1 as a sum of reciprocals of integers all of them greater than the largest integer, 6, already used in (4.1)? And then could we express the fourth 1 as a sum of reciprocals of integers, all of them greater than those used so far? And so on. If we can continue in this way, then clearly the answer to the question in the above problem is "*All* positive integers m."

Thus we can solve the above problem if we can first prove the following auxiliary theorem, or lemma:

Lemma: *For every positive integer* N, *the number 1 can be expressed as a sum of reciprocals of integers, all different from each other and all* $\geqq$ N.

As a matter of fact it turns out that we can prove this lemma and that we can in fact make the smallest of these positive integers actually *equal* to N. One way to see this is to make use of the following 'denominator increasing' formulas:

$$\frac{1}{2}=\frac{1}{3}+\frac{1}{2.3}=\frac{1}{3}+\frac{1}{6},$$

$$\frac{1}{3}=\frac{1}{4}+\frac{1}{3.4}=\frac{1}{4}+\frac{1}{12},$$

$$\frac{1}{4}=\frac{1}{5}+\frac{1}{4.5}=\frac{1}{5}+\frac{1}{20},$$

$$\frac{1}{m}=\frac{1}{m+1}+\frac{1}{m\,(m+1)}$$

and so on. (All of these formulas are easily verified directly.)

For instance, to express 1 as a sum of reciprocals of integers, all different and the smallest of them equal to 3, we could proceed as follows:

$$1=\frac{1}{2}+\frac{1}{3}+\frac{1}{6}$$
$$=\left(\frac{1}{3}+\frac{1}{6}\right)+\frac{1}{3}+\frac{1}{6}$$
$$=\left(\frac{1}{3}+\frac{1}{6}\right)+\left(\frac{1}{4}+\frac{1}{12}\right)+\left(\frac{1}{7}+\frac{1}{42}\right)$$
$$=\frac{1}{3}+\frac{1}{4}+\frac{1}{6}+\frac{1}{7}+\frac{1}{12}+\frac{1}{42}$$

It takes a little argument to see that this works for a general N as well as for the particular number 3, above, and hence establishes the lemma. The main point to be checked is that the process of successive replacements, using the 'denominator increasing' formulas, does ultimately yield denominators that are all different, so that this process doesn't have to be continued indefinitely.

Further Observations

We have now seen that for every positive integer m we can express m as a sum of reciprocals of positive integers, all different. That is, for every positive integer m there are positive integers $a^1<a^2<\dots<ak$ such that m is the sum of the 'unit fractions'

$$\frac{1}{a_1},\ \frac{1}{a_2},\dots,\ \frac{1}{a_k},$$

(5 1) $$m=\frac{1}{a_1}+\frac{1}{a_2}+\dots+\frac{1}{a_k}.$$

But it is now easy to extend this and express any positive *rational number r* as a sum of unit fractions. We first take any expression of r as a fraction m/n with positive integer numerator m and positive integer denominator n. Next, we find an expression for the numerator m as a sum of unit fractions, as in (5.1). Then we simply divide through this equation by n, thus expressing r as a sum.

$$r=\frac{m}{n}=\frac{1}{na_1}+\frac{1}{na_2}+\dots+\frac{1}{na_k}$$

of the unit fractions with denominators na_1 na_2 ..., na_k. We have thus established the following rather nice theorem:

Theorem: *Every positive rational number is expressible as a sum of unit fractions which are distinct (i.e., different from each other).*

You might wonder whether this theorem is old or new, well known or unknown. I will admit that it was completely unknown to me when I had the fun of discovering it for myself about a year ago as a result of reading the Hungarian Book problem we've been talking about. I will have more to say about this point in the second of these two articles.

Meantime, let us conclude by noticing just one more point. Since each rational number r is expressible as a sum of distinct unit fractions, there must be a smallest number—call it f(r)—of unit fractions whose sum is r. For instance, since

$$1=\frac{1}{1},$$

we see that $f(1)=1$.

$$2=\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{6}$$

and since no sum of three or fewer unit fractions can add up to as much as 2, we see that

$$f(2)=4.$$

For larger positive integers n it becomes increasingly awkward to evaluate the minimal number $f(n)$ of unit fractions whose sum is n. But we do have a simple way of giving an *underestimate* of this number. You no doubt recall the so-called 'harmonic series'

$$\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\cdots$$

And you also no doubt recall that by adding up enough terms of this series we can obtain as large a sum as we please. Thus for each positive integer n there is a largest positive integer m such that

$$\frac{1}{1}+\frac{1}{2}+\cdots+\frac{1}{m}\leqq n$$

Since the first m unit fractions

$$\frac{1}{1},\ \frac{1}{2},\ \ldots,\ \frac{1}{m}$$

are also the m largest ones, it is easy to see that the number, $f(n)$, of unit fractions needed to add up to n, exactly, is at least m. That is,

$$f(n)\geqq m.$$

I was curious enough to have our electronic computer at the University of Virginia run off some of these estimates. It turns out, for instance, that

$$f(3)\geqq 10,$$
$$f(4)\geqq 30,$$
$$f(5)\geqq 82,$$

and $f(6)$ is well over 200. According to a result recorded in the *Scientific American* for January 1965, page 116, a further analysis using computers has shown that $f(100)>2^{43}$

As n increases, it appears that $f(n)$ increases too, and at a greater and greater rate. One might wonder if anything could be said about this rate as n gets larger and larger. This problem is quite a bit harder than the ones we have been considering. As a matter of fact the answer was not known in 1961, when Herbert Wilf posed this as a problem for research (*Bulletin* of the American Mathematical Society, LXVII (1961, 456). The problem was solved in 1963 by P. J. Van Albada and J. H. Van Lint (*American Mathematical Monthly*, LXX (1933, 173) and independently by P. Erdos and S. Stein (*Proceedings* of the American Mathematical Society, XIV (1933, 130). It turns out that the larger n gets, the more nearly $f(n)$ behaves like the exponential function

$$e^{n-r}$$

where e is the base of the natural logarithm system and r is a certain number known as Euler's constant.

Biology in Indian High Schools

B. M. Johri and Manohar Lal
Department of Botany, University of Delhi, Delhi

UNLIKE their counterparts in America and European countries, biologists in India have a double task before them. First, they have to modernize the existing curricula and methods of instruction in biology, and thus strive to improve the public image of biology. Secondly, they have to convince the educational authorities of the importance and necessity of making biology a compulsory part of general education so that the citizens may serve the needs of a democratic country more intelligently. This problem is a part of another larger task before them, namely, removing the deficiencies of the existing system of biology instruction and bringing it in line with modern trends in science learning. While in other countries the status of school biology has been steadily improving with the all round academic improvement, the biology curricula in Indian schools and colleges have remained almost unchanged ever since they were introduced—in some places as far back as 150 years ago. An attempt is made in this survey paper to analyze the existing problems, and the steps being currently taken for improving the teaching of biology in Indian schools. Some of our problems are common to those faced by other countries; certain others are peculiar to India, and perhaps to a few other developing countries of Asia.

PRESENT STATUS OF SCHOOL BIOLOGY

In India there are two kinds of school courses—High School (2-year course after 8 years in pre-secondary or Middle school) and Higher Secondary course (3-year course after 8 years in Middle school). In high schools there is no biology curriculum as such; it forms only a part of the General Science curriculum. The student learns little beyond gaining some familiarity with a few plants and animals, and an elementary idea of digestion, respiration and photosynthesis. In most high schools there is either no laboratory work at all, or it is limited to the description of just a few plants and animals with the help of specimens, models, charts and slides.

BIOLOGY CURRICULUM IN HIGHER SECONDARY SCHOOLS

Much of the following discussion is concerned with biology in the higher secondary course (3-year course after the middle stage). It is taken as an elective subject by science students. A look at the old syllabus shows that the main emphasis is on structure, definitions and explanations. There is a traditional division of the course into Botany and Zoology, both of which are treated as a closed and completed

Paper presented at the First Asian Regional Conference on School Biology, held at Manila from December 4-10, 1966.

story where there is nothing to do except to remember the shapes of leaves, the forms of roots and stems, and the skeletal and other systems of frog as well as other animals. In this morphology-anatomy dominated curriculum, physiology, ecology, genetics, microbiology and the interrelations of plants and animals receive negligible attention. The curriculum presents an endless series of technical terms and lengthy descriptions which do not mean a thing to the beginner, and yet he must memorize them. In his struggle with these terms he often fails to appreciate the real odour of the subject. Another surprising aspect is that the study of human biology is completely omitted. Thus, the student remains completely ignorant of the functioning of his own body though he becomes familiar with the smallest bone of a frog and the details about the life cycle of a honey bee.

On the whole, the syllabus is primitive in content, too mechanical in approach, and too dull and boring to pursue. Perhaps the only object served by this scheme is that the students who manage to memorize a certain mass of facts and get through the examination become eligible for entrance into a university or a medical college. The syllabus together with the approach followed in its presentation, fails to give the students an insight into the fascinating world of life of which they themselves form such an important part.

This curriculum has been, in part at least, responsible for adversely affecting the status of biology and in making the subject the least popular of all sciences.

The reasons for these defects in curriculum can be traced to the origin of higher secondary courses. Surprisingly enough biology was not taught in Indian schools till as late as 1940, it used to be taught only in the Intermediate colleges, representing the first stage of a degree course. With the adoption of secondary system of education—in most states after 1945—elective and compulsory courses in biology were introduced. The biology courses at the Intermediate college level were rather hurriedly and, shall we say thoughtlessly, condensed to about 80 per cent, and prescribed for the higher secondary classes. It may be noted that the syllabuses of the Intermediate colleges which formed the genitor of the school syllabus were themselves quite outmoded—they were introduced at the turn of the present century. Thus, all the dead weight of the primitive Intermediate syllabus steeped into the school syllabus.

After the inception of the National Council of Educational Research and Training, Government of India, a new syllabus was drafted in 1964. Although there has been a lot of resistance to adopting even this not-too-modern curriculum, it is encouraging to note that several states have finally come forward to give it a trial. The principles followed in drawing up this syllabus are discussed later in this paper.

Reading Material Used by Students

The course content being largely similar to the Intermediate college

curriculum, the books used in secondary schools are generally the same as those used in Intermediate colleges. The paucity of suitable textbooks for schools is reflected in the fact that many boards of secondary education do not prescribe a textbook; they only recommend certain college books. The Central Board of Secondary Education in Delhi, for instance, recommends the following books:

1 *An Elementary Textbook of Zoology* by T. J. Parker and W. N. Parker; *Macmillan and Co.*, Ltd., London, 1952.
2. *The Frog* by A. M. Marshal, Macmillan and Co., Ltd., London, 1930.
3. *Skeleton of Indian Frog* by M. L. Bhatia; Maxwell Publication, Lucknow, 1952.
4. *A Class Book of Botany* by A. C. Datta; Oxford University Press, Bombay, 1965.

Most of these 'recommended books' are actually college level books of a rather specialized type, and are written by foreign authors exclusively or in collaboration with an Indian author. In addition to these there are many books by college teachers of botany and zoology. Most of the latter books are devoted exclusively to lengthy descriptions studded with hundreds of technical terms and their definitions. A large fund of biological information acquired during the present century finds no mention. The biological concepts and principles, and their application in daily life become obscure in the maze of descriptions and terminology. The books achieve little in developing the scientific outlook and experimental attitude of mind. The diagrams and printing leave much room for improvement. Since both curricula and existing textbooks demand a lot of memorization from the student, there is a tendency for further consolidation and condensation of the matter to its barest essentials. The result is the production of certain cheap or "made-easy", matter-of-fact books. These are nothing more than compendia of definitions and brief notes on the more important subjects which the student may memorize verbatim.

Thus, the reading material available to the student neither presents the subject in a scientific way, nor gives him a glimpse of the fascinating ways of plants and animals in their natural surroundings.

Laboratory Work

There is an appalling over-simplification of laboratory work. Field work and experimentation have no place in it. The emphasis on bookish knowledge is indeed so great that the students are often not acquainted with the beautiful fauna and flora of their own locality. In most schools the students attend the laboratory twice a week for 70-80 minutes on each turn. They spend most of their time in observing and dissecting the various plants and animals included in the syllabus, in making labelled diagrams of the entire or dissected specimens, in copying figures from charts, and in looking through the microscope. They also get a chance to observe the set-up of a few experiments in plant physiology. Since the laboratory hour is of short dura-

tion, the students rarely have the opportunity of seeing any experiment to its completion. The teacher, who has to look after a class of 30-35 students, often without a laboratory assistant to help him, cannot manage to demonstrate the experimental results on a quantitative basis.

Thus, there is no scope for the student to find out anything for himself through experimentation. The student's performance is judged by the quality of diagrams in his practical record book. Many 'good' note-books contain diagrams neatly copied from books and charts.

The laboratory work prescribed by most schools runs as follows :

Botany: Description and dissection of the types included in the syllabus for written examination. Demonstration of experiments in physiology, and identification of microscopic slides of tissues included in the syllabus for written examination.

Zoology: Dissection and skeleton of frog. Identification of animals and slides (microscopic) of specimens included in the syllabus for written examination.

School Teacher

The Commission on Secondary Education in India had laid down that the students in the higher secondary schools should be taught by post-graduate (M.Sc.) trained teachers. However, the salaries of teachers are not adequate to give them the dignity and status which their work demands. Their chances for promotion are too few. Teaching profession, therefore, attracts the least promising men and women, and there is an acute shortage of really good, trained teachers. In many schools science graduates teach biology for one, two, or even all the three years (i.e. classes IX, X and XI). Heavy duty (25-35 periods of 40-45 minutes each, per week) and poor remuneration prevent the teachers from putting their heart into the work, and they are often on the look-out for non-teaching, more prosperous jobs.

Even where trained post-graduate teachers are employed, the teaching remains stereotyped and sometimes even unbalanced. The teachers are specialized in classical biology—either botany or zoology. Depending upon his specialization, he may do full justice to one branch but may accord a stepmotherly treatment to the other. Quite often they influence the future choice of subject by the students studying under him. The teacher's initiative is often curbed by the stereotyped curriculum; his teaching becomes dull and lifeless due to the pressure of the dead weight of examinations which often demand little more than a good memory.

REFORMS—ACHIEVED AND ENVISAGED

The facts enumerated here tend to show, rather dismally, that the reformatory task before the Indian biologists is not only enormous but also difficult. They have to exercise restraint and patience in uprooting the evil which is several decades old and which has taken the shape of a vicious circle composed of several limiting factors. However, the brighter and encouraging side of

the picture is that given proper guidance and facilities, the Indian student is prepared to accept the change and turns out as meritorious as his counterparts in any part of the world. The rock of finance on which excellent schemes come to grief is one of the major hurdles. But in this respect we have been lucky in getting substantial monetary help from some friendly countries particularly the USA and USSR. With this assistance the Government of India has taken, during the past five years, many bold steps with a view to bringing an all round improvement in school curricula. Some of these steps are outlined below.

Development of a New Curriculum and Textbook

The National Council of Educational Research and Training approached one of the most eminent biologists, the late Professor P. Maheshwari, to set up and guide a Biology Panel. The Panel consisted of 16 representatives—professors, teachers and research workers from several universities and research institutions. This Panel has drawn up a revised curriculum and prepared a new 'Textbook of Biology for Higher Secondary Schools". The Chairman had maintained a close contact with modern developments in biology in other countries, and much as he would have liked to go hand in hand with the practices of the times, he had to restrain himself in the design of the curriculum and the textbook in view of the prevailing situation.

The members of the Panel considered several ways of approaching the subject and discussed their merits and demerits. Finally, they decided that, in view of the prevailing standards and practices of teaching in Indian schools, it would be desirable to adopt, for the time being, a modernized traditional approach. The members agreed that a wide acquaintance with a number of different kinds of organisms, their activities, habits and their tissues and organs, is essential and basic to the understanding of the general concepts of evolution, ecology, heredity, and cell physiology. This approach, in their opinion, combines not only the pedagogical advantage of proceeding from known to the unknown but also prevents students from getting lost in the intricacies of the more advanced aspects of biology.

They also decided that evolution be treated separately in two chapters, but an attempt be made to acquaint the student with this all pervasive principle during his study of the world of life. Biological phenomena common to plants and animals are to be discussed together as far as possible, but this should not be carried too far because there are several aspects of plants as well as of animals which deserve independent treatment. It was decided that technical terms be kept down to the minimum except where their use contributes to easier communication and understanding. Important biological discoveries are to be dealt with in a historical perspective to give an idea of how science progresses.

The book has been divided into seven, more or less independent sec-

tions. In the first section the student is introduced to the subject matter of science, particularly biology, and the characteristics of the living matter. A glimpse of the variety of plant and animal life prepares the student for a more detailed study of these forms in the second and third sections The fourth section treats the main physiological processes in animals and plants in a simple way. The fifth is devoted to a comparative account of the different modes of reproduction in the plant and animal kingdom. Heredity, evolution and ecology form the sixth section of the book. The epilogue to the book covers topics like human diseases, interdependence of plants and animals, and the role of biology in human welfare.

It is encouraging to note that almost all the schools under the Central Board of Secondary Education in Delhi and in some other states have agreed to give the new curriculum and the textbook a fair trial.

It may be pointed out that the late chairman (Professor P. Maheshwari) of the Biology Panel was not dogmatic and did not consider the new syllabus the only suitable approach. He was of the opinion that several agencies or individuals should be entrusted with preparing other versions of the subject and the schools should be free to choose the text best suited to their needs.

In the meantime, the National Council has also reprinted the BSCS Biology Textbook—'An Inquiry into Life,' at a low cost The related books on laboratory work and Teacher's Guide have also been made available. Because of the different background these books have a limited use, and an Indian adaptation of this work would perhaps be of immense help to teachers and students.

Recently, the Directorate of Extension Programmes for Secondary Education drafted a syllabus in General Science for Classes I to VIII with the help of specialists and science teachers drawn from various Indian States. This syllabus is now being re-examined and revised. The introduction of this syllabus will improve the primary stage of education and will make the introduction of reforms at the higher secondary stage much easier.

Laboratories and Equipment

The Government of India has been giving assistance to State Governments for the introduction of elective science courses in higher secondary schools. In addition, assistance was also given during the first two 5-year Plans for the strengthening of science through construction of Laboratories and purchase of apparatus.

Recently, a panel set up by the Committee on Plan Projects of the Planning Commission drew up laboratory designs and lists of equipment for higher secondary schools.

In-Service Programmes

The Directorate of Extension Programmes for Secondary Education has been organising a large number of in-

service programmes for the benefit of secondary school science teachers. These programmes have dealt with dynamic methods of teaching science, preparation and use of teaching aids, co-curricular activities in science, lesson plans, evaluation, etc. Several Extension Centres also organize workshops to acquaint teachers with the implications of the revised syllabus introduced in their States. These in-service programmes have brought a keener awareness among science teachers of the new concepts and techniques of science teaching.

Exchange of Science Teachers

In 1958, forty teachers in science, selected from training colleges and secondary schools in the different States, were deputed to study modern methods of science teaching in the UK, USA, and Canada, under the Government of India scheme for the strengthening of science teaching in the country.

On their return to India, the Directorate organised a 5-day seminar in July 1959 to pool the experiences which they gained abroad and to draw up a comprehensive programme of science education at all levels. The suggestions made by the group were considered by the All-India Council for Secondary Education, and were also incorporated subsequently in the programme of science education drawn up for the third Five Year Plan. This programme is being followed more extensively.

Television Lessons

A programme of television lessons on physics, chemistry and biology for the higher secondary classes has been introduced in Delhi since 1961-62. Each lesson lasts for 20 minutes, and is preceded by an introduction by the subject teacher for 10 minutes and followed by a review for another 10 minutes. The scheme was started for Class IX and has now been extended to Class X.

Science Clubs

A programme of establishing Science Club activities in secondary schools was initiated during 1967-68 by the former All-India Council for Secondary Education, and was continued by the Directorate of Extension Programmes for Secondary Education and the Department of Science Education of the NCERT. At present it covers well over 1,114 schools. A non-recurring grant of Rs 1,200 for the purchase of tools and equipment is given to each school covered by the programme. In addition to these, eight basic schools have established Science Clubs with a non-recurring grant of Rs 3,001 for each school.

The aim of the programme is to provide opportunities for experimentation in science with a view to stimulating the interest of young pupils studying science, besides encouraging the pursuit of science as a hobby. The facilities provided by the clubs are utilized by the members for individual and group projects, and the science teachers try to correlate the club activities with class-room teaching wherever possible.

In addition to School Science Clubs

60 Central Science Clubs to serve as energising centres have been established in selected training colleges where Extension Services Centres are located. A non-recurring grant of Rs 2,000 is given to each Central Science Club towards the purchase of equipment.

Science Fairs

Early in its programme of improvement of science teaching, the NCERT considered it necessary to introduce a programme of Science Fairs. This was to support the programme of science clubs and to encourage pupils, teachers and the public to take a deeper interest in scientific advances and scientific methods. The All-India Council for Secondary Education, at its second meeting held early in 1960, recommended that a programme of All-India Science Fairs should be organized, preferably on the first of December each year, followed by a Science Week when various types of programmes, such as science exhibitions, lectures, film shows, symposia and similar activities could be organised. During the year 1960, Madhya Pradesh conducted a State-wide programme of Science Fairs. In 1961, the 54 Extension Services Centres were requested to organise Science Fairs with the help of their associated schools, and an amount of Rs 500 was made available to each centre for this purpose. The response was very encouraging and a large number of schools participated in this programme and conducted a variety of activities. During the subsequent four years Science Fairs were held at 3 levels as stated below:

	1962-63	1963-64	1964-65	1965-66
District Science Fairs	—	—	283	264
State Science Fairs	—	2	2	5
Regional Science Fairs	56	80	77	79

National Science Talent Search

As part of its comprehensive programme of science education, the Government of India have formulated a programme of Science Talent Search under which promising science students of the final year in the secondary schools are selected through suitable procedures and given scholarships and certificates of merit. The main objectives of the scheme are (a) to identify boys and girls who possess a marked aptitude for science, (b) to stimulate scientific talent by creating a healthy competition for recognition of merit, (c) to encourage schools to take more active interest in the search for scientific ability, (d) to expose the talented students to the challenges in science, and (e) to build up a body of future scientists who will contribute to the scientific advancement both in the applied and pure science. The scheme will also help in bringing about improvement in the methods of teaching science in the schools.

The scheme was started in 1963 and is now running its fifth year. Every year about 350 talented students are selected for the award of scholarship on the basis of (a) An aptitude test, (b) An essay competition, (c) A project report, and (d) An interview by a com-

mittee of specialists. The students are required to pursue a course leading to a degree in basic sciences. For the first three years of study (for the B.Sc. degree) the awardees get Rs 100 p.m. as scholarship and a book allowance of Rs 100 per annum. The scholarship is continued beyond the B.Sc. stage if the awardee passes his examination in the first division and joins the M.Sc. class. After that it may be continued for another three or four years during his doctorate work in basic science. The scholar will be paid Rs 250 p.m. at this stage and Rs 350 p.m. at the Ph.D. stage. In addition, the tuition fees will be reimbursed. The Department of Science Education of the NCERT will try to place these scholars at the centres of Advanced Studies and at such Universities where well-known scientists are working. The book awards will also continue during the M.Sc. and Ph.D. stages at Rs. 250 and Rs 500 per annum.

As a follow-up programme the awardees are invited to attend a one month Summer School during the B.Sc. and M.Sc. stages. At these schools the students are offered an accelerated programme of science instruction, so that they can acquire enough knowledge and motivation to pursue a career of research in science.

Summer Institutes for School Teachers

This is a programme of in-service training of school teachers for a period of 4-6 weeks, sponsored jointly by the NCERT the University Grants Commission, and the U.S. AID. These institutes are designed to inspire the school teachers to continue learning in their fields so that they constantly strive to increase their understanding and competence. The teachers attending these institutes also learn new ways of teaching science, especially such methods as would enable the students to learn science by discovering truth rather than merely studying descriptive science. The programme had a small beginning in 1963 when only four institutes, one in each major science subject, were held. The positive impact of these institutes greatly encouraged the expansion of this programme, and in 1965 there were as many as 43 institutes, of which 8 were devoted to biology. In all 761 biology teachers have been benefited by this scheme

Participation of US National Science Foundation

The U.S. AID/India recently sought the cooperation of the U.S. National Science Foundation to implement a large scale, year-round programme of academic support to modernize curricula, laboratories and teaching aids. Accordingly, an Indo-American Conference on Scientific and Technical Education in India was held in New Delhi from May 1 to 5, 1966. It was resolved in this conference that the Government of India and NSF/AID will co-operate for the next few years in a programme of follow-up activities designed to make much more effective the summer institutes now going on in India. The follow-up activities include preparation of textbooks, teacher guides, and curriculum materials; strengthening of the libraries; and designing as well as manufacturing of

laboratory apparatus, etc A working conference held from June 20 to 27, 1966 at Srinagar has worked out the details of this programme, and with the grant made available by the NSF, this scheme would have much impact on the improvement of science in India

CONCLUSION

Ours is a race on many fronts. On one side we are called upon to catch up with the times—to imbibe and assimilate the recently accumulated fund of knowledge, without wasting any time. In other words, we have to pick up and reach where other countries already are. On another front, we have to fight with the ever-increasing demands in terms of trained teachers, laboratories, text books and other teaching aids. The expansion is required on such a vast scale that most of our efforts become greatly diluted, and the results therefore appear discouragingly disproportionate. To serve our needs best, we have to do more of indigenous thinking and effort, and in this we can derive much benefit from what other countries have done and from the generous help, both in cash and in personnel, which many friendly countries are so generously offering.

ACKNOWLEDGEMENTS

We are indebted to the late Professor P. Maheshwari FRS, who pioneered a team of biologists interested in the improvement of biology curricula in Indian schools and colleges. Many of the observations made in this article emanated from our discussions with that illustrious teacher. Thanks are also due to Mr. S. Doraiswami for furnishing some up-to-date data included in this article.

APPENDIX 1

ASIAN REGIONAL CONFERENCE ON SCHOOL BIOLOGY

Manila, December 4-10, 1966

RECOMMENDATIONS

I. On the Aims of School Biology Teaching in Asia

1. Develop and instil in students the scientific attitude of inquiry and experimentation.
2. Provide sufficient understanding of the concepts of biology to enable students to become worthy citizens of the world.
3. Provide the opportunities for a practical understanding of the methods of the biologists which will give them the confidence to attempt the solution of problems which they have to face in their individual and social lives.
4. Give students the incentive to pursue the study, at the higher levels, of biology and related fields.
5. Encourage respect and feeling for living things

To achieve the foregoing aims, the following criteria for the selection of content of secondary school biology in Asia are recommended:

1. It must inculcate the idea of science as inquiry.
2. It must consider the pertinent problems and needs of the community and emphasize the study of local *flora* and *fauna*.
3. It must be presented in a logical and coherent manner based on the following themes:
   a. The intellectual history of biological concepts.
   b. The change of living things through time (evolution).
   c. Diversity of type and unity of pattern in living things.
   d. The genetic continuity of life.
   e. Interdependence of organism and environment.
   f. Biological roots of behaviour.
   g. Correlation (complementarity) of structure and function.
   h Regulation and preservation of life in the face of change.
4. The class time allocated to the subject shall, ideally, be not less than 180 full hours
5. The content must correlate biology with other school subjects.
6. Consideration should be given to the best information available regarding students' learning processes.

Considering that biology plays an all-pervading and vital role in the life of every man, it must be taught as a required subject in all secondary schools.

Sufficient laboratory facilities for biology must be made available in all secondary schools.

II. On Teaching Methods and Teacher Training

A. Teaching Methods

1. Emphasis should be on practical laboratory work and field study in order to give the pupil experience in scientific inquiry. For proper implementation, the following points are suggested:
   a. Observations to be made should be guided by a list of questions.
   b. In planning practical work, existing facilities should be taken into consideration and improvisation should be encouraged.

(1) When no laboratory facilities are available, the following may be resorted to:

(a) Demonstrations, in which students take part in the planning. Each step must be understood by everyone, ensuring that each demonstration becomes a cooperative activity;

(b) Improvising a mobile laboratory table with supplies and equipment or unit kits that can be rotated among different groups in the class; home work may be assigned

(2) When partial use of the laboratory is possible, the above practices should be combined with use of the laboratory.

(3) When adequate laboratory facilities are available, these should be used to the best advantage.

c. Laboratory experiments should be planned to fit the level of the pupils being taught.

d. As much as possible, local biological materials should be utilized.

e. Emphasis should be laid on quantitative measurements. Accurate and systematic methods of recording and presentation of observations should be practised.

f. Interpretations and conclusions should be discussed in the class under the guidance of the teacher.

2. Group discussions and active participation by pupils should be encouraged to the maximum. Lecturing by the teacher should be minimized.

3. As much as possible, practical applications of biological principles should be emphasized.

4. Teaching aids such as specimens (preferably live ones), models, charts, films, slides, filmstrips, etc should be used to help present the lesson more interestingly and effectively

5 Written and practical examinations should be designed to provide the teacher with relatively accurate evaluation of the effectiveness of his teaching

6. Biological gardens and museums are useful means for effective instruction, and should be availed of.

7. Auxiliary readings to supplement the text should be encouraged

8. Pupils should be given incentive to collect information on topics of biological interest from sources other than books and should be encouraged to present this information in the classroom.

9. In case educational television is used, there should be close coordination between the producers of the programme and the teachers using TV materials in order to bring about maximum effectiveness.

B. Teacher Training

The pre-service curriculum in teacher training should have the following features:

1. A sound and strong training in modern trends and approaches in the biological sciences. This should be supplemented by adequate background knowledge in related subjects, including chemistry, physics, mathematics, geology, etc.

2. A basic psychological education.

3. A training in exercising different teaching methods including field techniques, laboratory skills, classroom management and administration, and in the use of various teaching aids.

4. A training in the organization of subject matter at different levels of complexity.

5 Instruction in the proper use of audio-visual methods and new technical developments in teaching aids.

6 Training on evaluation of the achievements of pupils and the effectiveness of his own teaching and training on evaluation of curricula, books and various instructional materials

The following should be considered as in-service and refresher training courses

1. Refresher courses which bring teachers up to date on the points recommended under the pre-service curriculum should be organized It is desirable for a teacher to keep himself abreast with modern trends in the biological sciences and should attend such courses as often as possible

2. Opportunities should be provided whereby teachers may acquire further experience in research and enable them to perform research on their own.

3 Seminars, workshops, conferences, etc, may be held whereby exchanges of ideas and experiences are brought among biology teachers in a locality, region, country, and different countries

III. On Evaluation in School Biology Teaching

1. A scheme of work, or curriculum, should be evaluated, aims examined and content analyzed, before being generally accepted. It should be tried out in the classrooms and evaluated in terms of feedback from teachers and pupils.

2 Formative evaluation should be major consideration in the development of curriculum materials.

3. Evaluation should consider techniques other than written tests and examinations, such as, observations of student behaviour, interviews, and development of skills through performance tests.

4 Evaluators should be acquainted with the objectives of the course, which should be explicitly stated so that in evaluating materials or student achievements, attention is directed towards both the content and the processes of science; in the construction of tests a tridimensional grid can be developed to help guide the evaluation

5. Teacher should be oriented on the philosophy of evaluation which will consider the broader aspects of evaluation. More specifically, training should be provided on test construction, with particular emphasis on test items which tend to measure not simple recall, but comprehension, ability and skill in analysis of data, application, and other processes of science. Such training should be provided in both pre-service and in-service levels of teacher education.

6 Well-designed test items, developed by experts (subject specialists, teachers, and psychometricians) should be made available to teachers to serve as models, the teachers should be encouraged to develop his own battery of tests for his particular course.

7 The foregoing recommendations should be made available to all those involved in various aspects of evaluation, such as, the administrators of national examinations, school administrators, educational organizations, and teachers.

8. A committee or an organization should be formed to enable developers of curriculum materials to meet and exchange information and ideas on the improvement of evaluation practices.

IV. On the Relation of School Biology to Post-School Biology and Every-day Life

1. The content of the course should be comprehensive enough for students and should take into account the immediate socio-economic environment. The course should aim at developing appreciation of nature and at the intellectual, aesthetic and utilitarian values of biology

2. The content should take into account the main areas of biological science as well as the recent advances in these areas Adequate emphasis should be on both the content and processes of science. The main themes of the course would be biology as an inquiry, and the historical development of biological concepts. These schemes should be all pervasive.

3. Ways and means should be found to make the pupils appreciate the "nature of biology, its modes of inquiry, its major theories and conceptual inventions," through activity, inquiry and discussion As much as possible the facts and problems immediately connected with the country's welfare be used as materials of instruction.

4. The laboratory should be the focal point of all instructional activities which must be investigative

5. The links between pure and applied biology are close and lines are not easily drawn Applications of biology help to make biology teaching more lively and relevant to every day life, and in a developing country applied biology is vital and should be taken for granted

V. On the Role of the University and Other Agencies

It is recommended that there should be effective communication among scientists, science educationists, teachers and students in the secondary schools Possible ways of achieving this communication are the following

1. Advising on the development and design of biology programmes to be taught at secondary levels. This may take the form of curricular revisional adaptations or reorientations of emphasis so as to meet local requirements and conditions.

2. Stimulating use of effective teaching methods.

3. Coordinating programmes for biology teachers in training college.

4. Advising on examinations

5. Conducting refresher courses.

6. Supporting researches and awarding scholarships, including the international exchanges of secondary school teachers in order to enable them to study new developments and observe classroom instruction.

7. Publishing articles on biological researches and experiences of educationists relating to biological education

APPENDIX 2

ESTABLISHMENT OF AN ORGANIZATION ON SCHOOL BIOLOGY TEACHING IN ASIA

I. Justification

The recently concluded conference on school biology teaching in Asia has strengthened the conviction among the many participants of the need for an organization that will, among other things, permit a continuing exchange of ideas, information, and materials relative to the improvement of school biology teaching in Asia. Such an organization, it is felt, would serve as a vehicle for following up, implementing recommendations and stimulating the initiation of action programmes among the participating countries.

At the last session of the conference, an executive committee of five was elected to assume the responsibility of setting up such a regional organization on school biology education.

The following were elected:

Chairman: Dr Liceria B. Soriano, Bureau of Public Schools, Manila, Philippines

Executive Secretary: Dr Dolores P. Fernandez, Science Teaching Centre, University of Philippines, Quezon City, Philippines.

Members: Prof. Hilary Crusz, Department of Zoology, University of Ceylon, Peradeniya, Ceylon.

Prof. B. M. Johri, Department of Botany, University of Delhi, Delhi, India.

Dr Kazuhiko Nakayama, Graduate school of Education, International Christian University, Tokyo, Japan.

In view of the foregoing considerations, it was decided to submit this proposal for assistance to establish an Asian Organization on School Biology.

II. Objectives

1. To establish an organization, a major function of which would be to follow up the recommendations and resolutions of the First Asian Conference on School Biology through the participating countries and those which did not participate.
2. To establish a clearing house for information regarding school biology programmes from various countries.
3. To prepare for the next conference on school biology to be held in Tokyo, Japan.
4. To have an organization which will assist in the exchange of biology professors among different countries, particularly the exchange of experts in biology teacher in-service education.

Further comments on statement of objectives:

1. Follow-up work would include such activities as drawing up a mailing list of Asian biology educators, contacting people in Asian countries who are in positions to effect changes in school biology teaching, preparing and securing suggestion from biologists and educators on possible topics for discussion and study at the next biennial conference, setting up a secretariat for this organization, plans for holding periodic (biennial) conferences.

2. The clearing house should not just be a data centre but, hopefully, it should be an active centre for new thinking in the area of school biology. A newsletter published by this clearing house would keep the member countries informed of developments in the different countries.

3 It is expected that five members of the Executive Committee (or their representatives) will meet in Tokyo, Japan, in December, 1967 to plan the next biennial conference. At this planning conference, a tentative programme for Tokyo conference and details pertaining to it will be discussed. It should also be possible at this planning conference for the Executive Committee to discuss matters pertaining to objective 1 and 2.

4. The organization should consider means of bringing biology teachers from other countries to assist in running institute programmes for biology teachers. From such exchanges, publications on teacher education materials suitable for Asian countries may result

III. Plan of Operation

1 The temporary location of the organization will be:

Science Teaching Center
University of Philippines
Diliman, Quezon City

2 Each member of the Executive Committee will receive a copy of each official letter or communication of the organization so that each is continually informed of details of operation and other matters pertaining to the organization.

3. The Executive Committee will select a name for the organization and draft a constitution, which will then be submitted to the other members (participants at the conference) for approval.

4. As soon as the secretariat has been set up in the Bureau of Public Schools or the Science Teaching Centre, the Philippine members of the Executive Committee will take the initial steps to implement the objectives of this proposal.

Where is Science Heading?

An Interview with Robert Oppenheimer

Over the last fifty years, the sum total of our knowledge has been profoundly transformed by the lightning progress of science. We would like to know which recent discoveries, in your opinion, have irrevocably transformed our vision of the universe or answered any major questions about it.

No definite cosmological answer has yet been supplied. There are those who maintain that the world had no beginning, but their arguments are quite weak. At any rate, the present state of knowledge is still compatible with the views of people who, like myself, believe the universe to be an historical phenomenon. It is no accident that Heraclitus and Parmenides are both represented in our present-day cosmogony. I think there may have been an evolution that began about twenty thousand million years ago—perhaps earlier. In any case, there is no earlier evidence. The human experiment seems to be finite in time, and what we are unable to discover does not belong to science.

What is not very clear either is whether the universe is open or closed. The natural interpretation is that of a closed universe. But if you go far enough you cannot return. Today we are discovering new galaxies. We can see further. Thanks to radio-astronomy we can see much further still. The speed at which the galaxies move away from us is greater and greater. If it approaches the speed of light then we do not see them at all, their signals do not reach us. Then how can we know whether the universe is finite or infinite? All science must bring man back to humility. We are always finding limits to our knowledge, and man's imagination has proved limited compared to nature itself.

And how do you see the beginning and the end of the earth?

The question of the earth's formation is still open. Future research, particularly space studies, will teach us a lot. The most currently accepted calculation today dates the appearance of the earth four thousand million years ago. We probably owe its formation to the condensation of dust left over from the formation of the sun like Saturn's rings. But we are not sure. As for the end of the earth, we still do not know enough about the evolution of the sun to predict what will happen. Sources of energy are finite, so the sun cannot last for ever. It will cool without a doubt. Then the earth will spiral around until it touches the cold, dead dun. It might also explode, but I should not think that is likely. When will the end of the earth be? Not for another ten thousand million or twenty thousand million years.

How did life appear on earth?

By chance, I think, during a phase when the atmosphere was chemically

Reprinted from SCIENCE TODAY A Progress Report in Reality No. 154 September 1963.

unstable. What I want to know is how organic molecules were formed. This could have happened by chance as well. But, even though by chance, it could still have had a purpose. For, while the adaptation and evolution of living matter can be explained by a change in molecules, this does not prevent evolution from leading to greater and greater complexity. In this respect, but in this respect only, I think along the same lines as Teilhard de Chardin. Chance and mechanics are closely interwoven. It is inevitable.

For the sake of clarity I would like to mention here and now an idea that I put great stock in. It happens to be part of the newly-acquired knowledge you spoke about earlier, and which sheds such a decisive light upon our understanding of the world. This is the law of complementarity. When my friend Niels Bohr, the great Danish physicist, was studying the quantum theory thirty years ago, he discovered one remarkable feature: in atomic physics, there comes a time when it is impossible to study all characteristics at once; you must choose some, and this implies neglecting the others. For example, each of the electron's two states —the wave and the corpuscle—can only be determined separately. Determination of the one means losing knowledge of the other. And yet both correspond to the same reality. The observer must therefore make a choice, and imperative separation.

Bohr said that atomic physics, which dominates all physical phenomena on the molecular scale, provides an exact image of the human condition, in which there are mutually exclusive ways of using words, and even our minds or souls. These ways can be independently chosen but not combined

Do you think that life exists elsewhere than on earth?

Probably. This depends on how you define life, but I believe you will find functions, propagation, mutation and stability everywhere in the universe. But you won't find any of these tomorrow. On the moon? That would surprise me. There is no organic matter on the moon to create life. There is no water. It's difficult to have life without water. As for Mars and Venus, I am not sure. I doubt it, but then I am no expert. The planets of other suns? It will take a thousand years to reach any of them, so how can we meet? If we extend the human life span, we can, of course, but then we will no longer be men. This is sheer speculation. It is interesting, I admit, but I certainly do not expect an answer during my lifetime.

Some of America's best-known scientists have said that before very long science will be in a position to supply a mechanical explanation for all phenomena. What do you think of this assertion?

First of all, I do not think there is anything in nature that cannot be explained. Look at a wave breaking in the Atlantic. It has a shape, a position, and a time; it can be explained. But I can't explain it, and man will never explain it. Why? Because to do so he would have to explain every wave in the sea. Human knowledge is finite,

and so is human experience. This is not a pessimistic view; it simply corresponds to our world.

Obviously, the nature of the world will be understood in its structure some day. Then you will be able to explain anything—but not everything. When you try to explain everything, you run into an internal contradiction. Before you can understand, you have to simplify, and the moment you simplify you are no longer true to life. Certain observations must be excluded by the simple fact that one is observing. At this moment we are speaking together. You are listening to me attentively. There is noise all around us; and yet you do not hear it. The idea that scientists might have an answer to everything some day is not only false, but is even repulsive to me.

Then you minimize the decisive part played by scientists, in our world?

Because of scientists, our present no longer resembles our recent past, and our future is an unknown quantity. Our era is the era of science, but you must not forget that science has two aspects. One is the search for truth We try to reach a better understanding of nature and of ourselves as part of nature. The other, the source of technology seeks to change the world and to satisfy our needs. Why shouldn't we feel disturbed? Even in pure science a discovery is a source of anxiety. Niels Bohr said one day: "I never get an idea without wanting to commit suicide at the same time.

You are not a follower of the parapsychological sciences?

No. But why use this term? There is no contradiction between the natural sciences and certain psychological phenomena that are neither sufficiently studied nor understood. How, for example, can you explain communication between men without words or other recognized signals? I know a lot about my friends that they couldn't tell me. How have I learned it? We know a great deal about other people—their intentions and their emotions—without knowing how we know all this. A great actor knows how to tell others what he feels, but he can't explain it. A great part of one's life consists of love, and everything that is emotional has as yet been very scantily explored. The keys exist, and they are many, but we are not aware of them. We shall not find these keys by using mediums. I do not believe that we can enter into contact with the spirits of the dead.

Hasn't our conception of time changed during the last fifty years?

Certainly. Take the notion of irreversibility. For a long time man has tried to explain (and today he has partly succeeded) how the irreversibility of human experience can be compatible with the reversibility of the laws of mechanics. The irreversibility of discoveries, in effect, makes science cumulative. We should be suspicious of all political proposals based on the hope that man will forget what he once knew and knew how to do. For example, many scientists think we could rid the world of atomic weapons. But it would no longer be possible to recreate the world as we know it twenty years ago. Men know how to make these weapons

and the knowledge will never be forgotten You cannot re-create past illusions.

The same holds true for man's place in the universe. It is not all that long ago that it was possible to believe that man was the centre of the world, that he had a privileged place in the universe. Today we know the position of the earth in the solar system We know that hundreds of thousands of millions of galaxies exist beyond the range of the most powerful telescopes. Man's dignity and responsibility can never again be based upon a microcosmic notion of his condition.

But while cosmological concepts have been greatly enlarged, men now realize that, as far as they are concerned, their condition will not change for a long time During a human life span, transformations are much more rapid than in the past. Conditions around us change constantly, but man remains the same.

Does he really remain the same? Don't you think that man is perfectible?

Certainly, as far as knowledge is concerned, and also as far as power is concerned. He is capable of doing more and more things. But moral progress? This does not seem to me to be the case at all. In science the only direction is forward. You always learn more, even when you learn you have made a mistake. But if you try to apply this example to man's condition, if you claim, for example, that the great progress made in electronics should be accompanied by moral progress, then you are confusing two different types of phenomena. The regression of science is absolutely incompatible with its continued pursuit. Moral regression, however, is always possible. The man of tomorrow may know more and do more, but will he be better? I hope so, but I really haven't too much faith.

You have no faith in the possibility of genetic changes to improve the human race? You don't believe in eugenics?

Do you mean the creation of a superman? That is of no interest to me. I am interested in man as he is. Once we are certain of the consequences, there will obviously be voluntary eugenics but my main hope is that it would not be under governmental jurisdiction. Eugenics as an official doctrine would be horrible. Besides, I have no use for those eugenists who tell other people not to have children. They always happen to be the fathers of big families.

Do you think the world is heading towards government by scientists?

No. I certainly hope not. But I also hope that men in power will acquire an understanding of scientific discoveries, technological opportunities and the spirit of science—like that great patriot and universal man Thomas Jefferson. I know this is asking a great deal of a politician. The most important part of present-day knowledge did not exist when he was in school. For a man of fifty, almost everything he should know has been discovered since the end of his education. Do you know that, when one counts all the men who have brought new contributions to science and technology since the beginning of

history, ninety per cent of them are still alive?

What do you feel a statesman should know about science?

He should know how to learn. He should take the trouble to find out in what fields scientists are working. That may not be easy, but it is vital for a man in politics to know the nature of science's certainties and uncertainties.

A few years ago you described the Russo-American deadlock as two insects shut up inside a tube and obliged either to live together or to destroy each other. Don't you think it possible that one of the two adversaries might find a way out?

Of course, a lead caused by sudden technological progress is always possible, but only for a short time. I do not see it as an offensive weapon. Some people imagine, for example, that a gas might be used to plunge an entire country into a state of lethargy and hypnosis for two weeks, thereby annihilating its resistance. Such a method does not seem to me to be technically feasible. On the other hand, certain defensive methods may be devised. I do not expect much in this respect, either.

I believe that if there is a way out, it will come from politics and not science. For example, look how the people of Latin America have acquired the habit of not fighting wars. Upon a habit of this nature could be founded political institutions with the task of maintaining peace, not only among the weak but also among the strong. Then the problem would be not to make peace but to recognize it as a permanent state. Of course there is a great danger in modifying political institutions in this direction: we would have to make sufficient allowances for freedom, for differences, for opportunities for historical transformations, and for the possibilities of progress. But disarmament cannot be the first step. The first step will be the recognition of this fact: the absence of world war.

Can science help found a universal morality?

This is premature talk. I believe that morals and traditions will never be universal. But what I have just said—the recognition of the impossibility of fighting a world war--could become the central part of a universal morality. And why shouldn't Christian sensibility, that precious part of human sensibility, lead to something universal? If so many statesmen in China, Japan, India and Africa have been converted to Christianity, it is because they found in it the meaning of good and evil, the meaning of love and the meaning of charity. I believe that the strength and the soundness of Christian sensibility have changed the world at least as much as technological development.

National Dairy Research Institute—Karnal

THE National Dairy Research Institute at Karnal in the Punjab is a leading centre of dairy training, research and extension in the country. Established at Bangalore in 1923 this Institute has developed from the old Imperial Institute of Animal Husbandry and Dairying (later designated as Indian Dairy Research Institute) to its present form of a national organization.

Early Activities

In the early stages the activities of the Institute were mostly confined to (i) organization of dairy training courses to provide dairy technicians and husbandrymen for the Industry (ii) cross-breeding experiments with imported Ayrshire and Holstein breeds for increasing the milk producing capacity of local cattle and (iii) investigation on the feeding and management of dairy cattle.

National Dairy Research Institute — Karnal

Origin and Growth

The Imperial Institute of Animal Husbandry and Dairying was started on the premises of the old Military Dairy Farm at Bangalore in 1923. The Military Dairy Farm at Wellington (Nilgiris) and Karnal (Punjab) and the Government Creamery at Anand (Gujarat) were later on attached to the Bangalore Institute to serve as sub-stations.

Dairy Training

A two years' Indian dairy diploma course was started in 1923 at Bangalore. This course was also instituted at the Allahabad Agriculture Institute in the same year. In 1923 a fifteen-month post-graduate course leading to Associateship of the Institute and short-

Printed with the kind permission of the Director.

term practical training courses in modern Dairy Farming and Technology were also started at Bangalore.

Re-organization of the Institute

The Government of India decided to establish the National Dairy Research Institute, Karnal (Pb.) on the premises of the Cattle Breeding-cum-Dairy Farm. The farm had an extensive cultivable area of about 2000 acres, and was stocked with pedigree herds of Sahiwal, Tharparkar and Red Sindhi cattle. As a consequence, in August 1955, the existing farm at Karnal was merged with the new National Dairy Research Institute while the Indian Dairy Research Institute at Bangalore was converted into the Southern Regional Station of the main Institute.

Fully developed, the National Dairy Research Institute will consist of the main Institute at Karnal, and three regional stations. The Karnal Institute will have seven Research Divisions in the subject of Dairy Husbandry, Technology, Bacteriology, Chemistry, Engineering and Extension and a Division of Dairy Education and Training (with an attached Dairy Science College) a Section of Economics and Statistics and a Library and Museum. As regards the regional centres the Bangalore Institute is already functioning as the Southern Regional Station and is being provided with additional facilities. The Western Regional Station was established at the Aarey Milk Colony, Bombay in 1962 while steps have been initiated for the establishment of the Eastern Regional Station at Haringhatta, West Bengal.

Achievements

In the short span of eight years, since its foundation in 1955, the Institute has made good progress Buildings for the Dairy Engineering Division, Experimental Dairy, Dairy Science College, Administrative Block, Students Hostel, New Rest House and a number of residential quarters have been completed.

Roads have been built and a water supply tank and a sewage disposal plant have been installed. Modern equipment for milk processing and manufacture of milk products, equipment for mechanizing farm operations and major items of laboratory equipment have been obtained. A library has been set up and equipped with a large number of reference books, back numbers of journals and important current periodicals pertaining to dairy science and allied subjects.

The following is a brief account of the activities in different fields:

Farm

The programme of cultivation of fodder includes the cultivation of jowar, maize and cowpeas during *kharif* and berseem, gram and oats in the *rabi* season on a farm area about 750 acres in each growing season. Lucerne is extensively grown as perennial crop. The institute depends only on home grown fodder for feeding the dairy herd. About one third of concentrate-feed requirements is also met from home production.

A new fodder crop, Hybrid Napier

Luxuriant hybrid Napier Crop

EB4, (called gajraj in Hindi) has been successfully grown at the Institute. A cross between the native bajra and elephant or napier grass this hybrid variety gives yields as high as 150 tons per acre per annum and is also very nutritious. It grows to a height of about 6-10 feet and produces profuse foliage. Root slips are used for propagating the grass in lines. The crop can grow well in any kind of soil, except clay and water-logged soils. It can be grown in dry and wet regions but cannot withstand high altitudes and frost conditions. Heavy fertilization with organic and inorganic manure, and frequent irrigation are necessary to get best results.

Sowing should be done either immediately after winter or during the monsoon season.

The crop is ready for first cutting two to three months after planting. About 5 to 6 cuttings may be obtained in a year. It should be fed green to cattle. If allowed to mature, it becomes less palatable. Surplus fodder can be conserved in the form of silage.

Dairy Herd

The farm maintains about 1000 pedigreed animals of Tharparkar, Red Sindhi and Sahiwal cattle and Murrah buffaloes and each year about 150 high grade bull calves are distributed to different states for grading up work. The milking herd consists of about 200 cattle and buffaloes with an average production of 1800-2000 litres of milk a day. The average milk yield per lactation of 305 days for Red Sindhi and Sahiwal and Tharparkar cows is 3,870 and 5,500 litres respectively. Outstanding Tharparkar and Sahiwal cows have given milk ranging from 4000-5000 litres in a lactation.

Economy in Milk Production Costs

The cost of milk production influences to a large extent the consumer price. The cost of milk production in urban and rural areas would naturally be different from what it would be on organized dairy farms.

Cost-studies in milk production conducted at the Institute have indicated that the feed costs which were the highest, can be lowered by replacing costly concentrates by green fodder and legumes. For instance, a ration of 20 Kg. of green oats plus 20 Kg. of green berseem supplies nutrients for maintenance, as well as the first 4 Kg.

Institute herd

of milk. For higher yields, concentrates may be fed at the rate of 1 Kg. for every 2 Kg. of milk.

Factors such as days in milk, dry days and total milk production also have a large influence on production costs.

Depreciation charges can be kept low by minimizing replacement in the herd and finding out ways and means of lowering the cost of raising calves.

Labour cost distributed over a larger total production of milk would naturally have a salutary effect in reducing cost of production.

Economy in Calf-raising Costs

Raising calves in a dairy herd is expensive. But, it is necessary for scientific cattle husbandry. Calf-raising costs affect the cost of milk produced by cows, because calves need milk and they have also to be retained in the herd to replace older animals. For this reason, the female animals are neglected by the farmers. The cost of raising calves has, therefore, to be reduced so that the farmer can afford to maintain them.

Feeding is the most costly item in calf-raising. Studies conducted at this Institute have shown that there are three ways to reduce the cost of feeding (i) substitution of milk ration by suitable calf starters (ii) lowering the protein of the feed ration and (iii) reducing the age at first calving.

While research for suitable milk substitutes has yet to begin, work has been done on the other two aspects.

The results indicated that young growing calves can be maintained in good condition without any adverse effects on growth and maturity by feeding 2.5% less protein. This will lead to substantial economy in feeding cost.

The recent introduction of progeny testing programme, systematic breeding and better managerial practices during the last five years or so has had the desired effect of lowering the age at first calving.

Distinguishing Cows' and Buffaloes' Milk

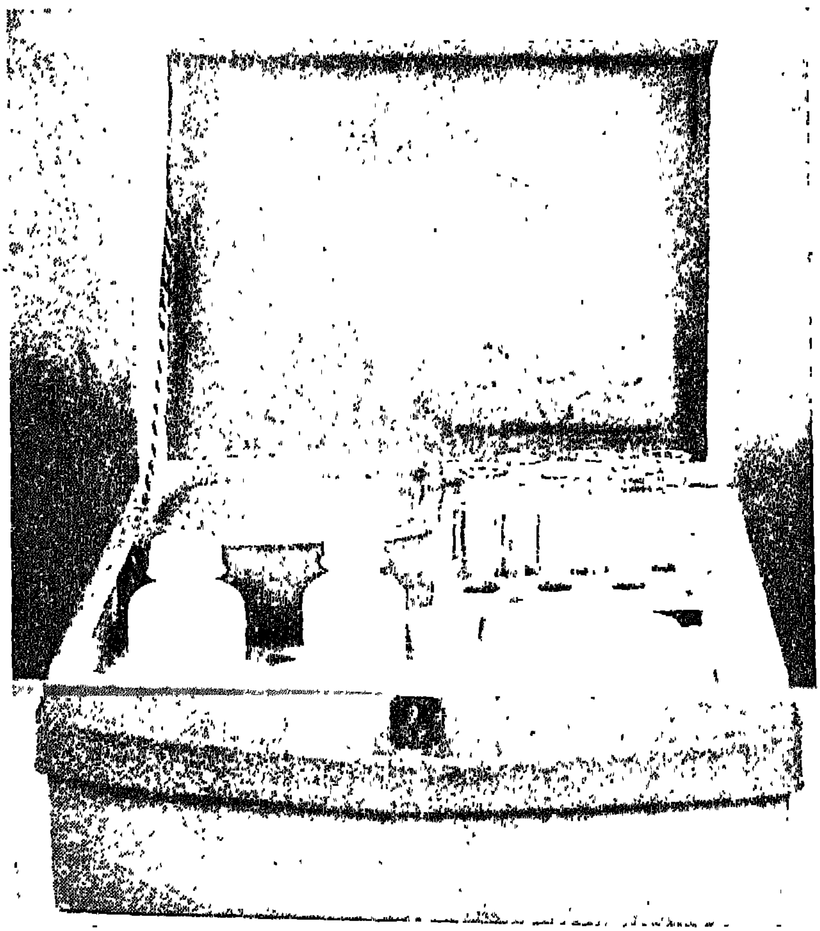
Milk is marketed in India as buffalo milk and mixed milk of cow and

buffalo. It is a very common practice to adulterate cow milk with watered buffalo milk. Many of the milk supply schemes are now faced with this problem.

This Institute has succeeded in evolving a reliable, sensitive and accurate method for distinguishing between cow and buffalo milk. The newly developed test is named Hansa Milk Test.

Hansa Milk Test

The common method of diagnosing diseases is to examine blood samples for their serological reaction. Anti-sera are prepared which contain antibodies. These antibodies are produced in experimental animals when foreign protein are introduced into their blood. The anti-sera are collected from the animals and non-specific antibodies removed. The remaining anti-sera forms the anti-serum for the specific protein. The anti-serum is then added to the blood samples and the disease can be diagnosed.



Hansa milk test kit

The Hansa Test is based on the above principle. Skim milk is injected into rabbits and the antibodies produced are collected and purified to make the specific anti-serum. When this anti-serum is added to the buffalo milk, it flocculates or groups together into large sized particles which can be seen easily.

A kit box containing the equipment to perform the test in the field has been designed. Details regarding its supply may be had from Dairy Extension Division of the Institute at Karnal.

Dairy

The new experimental dairy is designed to handle 8,000 litres of milk daily and has modern equipment for processing milk and manufacture of butter, ice-cream, cheese, butteroil, ghee, milk powder, and condensed milk on a semi-commercial scale. It provides facilities for the training of the students in market-milk processing and dairy plant operations.

Milk processing

Preparation of cheese in village

Research on various technological aspects connected with the collection, transport, processing, packing and distribution of milk and milk products and economic utilization of by-products are conducted.

Cheddar Cheese

Surplus skim milk can be economically converted into cottage cheese. With this object in view various stages in cottage cheese manufacture have been studied and standard procedures have been devised.

In western countries cheddar cheese is made from cow's milk. Conditions for production and ripening of cheddar cheese have been standardized there. *Buffalo milk differs from cow milk in* chemical composition, buffering power etc., and therefore variations in manufacturing stages are expected.

Preparing cheddar cheese

Butter Colour

The use of colour in butter making is necessary for consumer appeal. The colouring material for this purpose is derived from the pigments found in the seed skin of the anatto plant. In India, the need for colour is greater than in most other countries, since most butter manufacturers use the white cream of buffalo milk here. At present the butter colour is imported. A suitable procedure for extraction of a colouring material for butter has also been developed.

Brisk Milk Fat Test

A simple test for determining fat in milk and milk products has been developed at the National Dairy Research Institute, Karnal. This test, named Brisk Test uses a reagent made from common laboratory chemicals-alkalis, buffering agents and mixtures of alcohols. The test has been found to be very accurate and can be used like a Gerber Test in dairy plants and milk collecting centres. The test is particularly useful for finding out fat content in sweetened milk products like-ice-cream, chocolate milk, and condensed milk because the charring or decomposition of milk sugar by sulphuric acid does not occur in this case.

Starter Culture

The manufacture of quality milk products like cheese, butter and dahi requires the use of good quality starter cultures. Studies were undertaken to (a) determine the production of flavour compounds and (b) compare the growth rates of starter organism in cows and buffaloes milk and (c) find out the suitability of cows' and buffaloes' milk for starter activity tests. It was inferred that the total acidity produced by starter activity in buffalo milk is more than that produced in cow or re-constituted milk.

Bacterial Rennet

In India, there is a sentimental objection to the consumption of cheese manufactured from animal rennet. As the product is highly nutritive and there is also a demand for it in the country, studies have been undertaken

to find out suitable substitute for animal rennet. An enzyme extract from bacterial source capable of coagulating milk and yielding good quality cheese was obtained. It can be isolated as liquid or powder.

The post-graduate wing of Dairy Science College was instituted in 1961 and the M.Sc (Dairying course offering specialization) in the fields of Dairy Husbandry, Technology, Chemistry and Bacteriology was started. The B Sc. (Dairying) course was bifurcated into two courses, one in Dairy Technology and the other in Dairy Husbandry to afford specialization in these areas.

In addition to the regular training programme of the institute, special tutorial workshops, attended by Dairy teachers from the different dairy training centres of the country were organized during 1961 and 1962 in collaboration with the FAO and UNICEF. The object of this workshop, the first of its kind to be organized in the country was to enable teachers develop the faculty of objective thinking, and to receive training in how to teach dairy students at the diploma level. Intensified theoretical and practical training in different aspects of dairying science as well as in the principles and methods of teaching was given in these workshops.

Specialized training courses in Dairy Extension (three months) and Dairy Engineering (10 months) were organized from November 1962 for participants from State Governments as well as private candidates. The Board of Dairy Education constituted by the Government of India for supervising the Dairy training programme in the country and co-ordinating the training activities of different training centres, continued to function effectively.

Extension

A nucleus extension unit was established at the Institute late in 1962. The programme of this unit includes the introduction of cooperative milk production in villages and its collection at village centres. It also includes demonstrations for fodder production and silage making in the extension villages using audio-visual aids In support of field work involving also visits of technical experts to dairy plants, publicity material in the form of pamphlets, a monthly magazine entitled 'Dairy Extension', radio broadcasts, simple hand-outs, and other audio-visual material was prepared and used. In the field of extension research, evaluation of research work through pilot studies on Hansa Milk Test, the Brisk Milk Test and Hybrid Napier Cultivation was initiated. A special field project on sanitizing mixture for cleaning milk utensils in villages was begun. Field testing kits for Hansa Milk Test and the Brisk Test were developed and fabricated for supply to several interested parties in the country.

Southern Regional Station, Bangalore

With the establishment of the National Dairy Research Institute at Karnal, the Indian Dairy Research Institute at Bangalore, which has been functioning as the national centre for

the dairy research and education in a small way for past 25 to 30 years, began to operate as the Southern Regional Station of the National Dairy Research Institute. This station is devoting itself chiefly to research on cross-breeding of cattle with reference to improving milk production and on problems having a special bearing on dairy development in South India. It continues as a centre for artificial insemination work in connection with the key village scheme of cattle development. It also functions as a central seed bull Depot for the collection, and distribution of semen from Jersey, Holstein and Russian (Kostromakaya) bulls maintained on the farm and other ap-

Interviewing a farmer

proved Zebu sires for improvement of cattle by artificial insemination in other parts of the country. The Southern Regional Animal Nutrition Centre and Central Artificial Insemination Station of the Indian Council of Agricultural Research are also located at this station for dealing with problems of cattle improvement

The Institute offers three types of instructional courses namely:

1. The Indian Dairying Diploma in Dairy Technology and Dairy Husbandry (two years).

2. Short course in Dairying (two months) and

3. Training of Honorary Research workers in research methods of Dairy Science and in post-graduate research work leading to M.Sc. and Ph.D. degrees of universities.

Besides improving milk production, some other current problems of research are (i) processing and prolonging the storage quality of milk and milk products (ii) detection of adulteration of milk, butter and ghee (iii) devising quick tests for assessing the quality of milk and (iv) production of bacterial rennet for cheese making.

Western Regional Station, Aarey, Bombay

The Western Regional Station of the Institute was established at Aarey Milk Colony, Bombay and an officer in charge was appointed. A nucleus herd of Sindhi Cattle was located and research projects were formulated.

Similarly the Eastern Regional Station of the National Dairy Research Institute has been established in February 1964 at Calcutta with headquarters at Central Dairy, Belgachia, Calcutta.

The programme of these stations, envisages the development of facilities for research of immediate and applied importance.

Some Activities from *Science-Teacher's Handbook, Classes I–V*

THE following activities have been taken from the book Science for Primary Schools, A Teacher's Handbook to be published by National Council of Educational Research and Training, New Delhi The activities are from class V material for the Unit I, i e, Air Water and Weather

— *Editor*

INVESTIGATION : HOW DO WE KNOW IF THERE IS AIR IN A BALLOON?

1. *Air is Used to Inflate Things*

Children and adults alike know that they often inflate things—'blow them up' with air. When they see a tyre or a football or a balloon, or even a paper bag inflated, they are seeing the result of air pressure inside the inflated object. The object feels hard—it resists being compressed or dented—because of the air pressure inside it. Students at this level are well aware that air is a material substance Now they can see that this material substance exerts pressure. This is the understanding which underlies this major concept—not merely that objects can be inflated, but rather that air can exert pressure—sometimes a very great pressure

1(a). *Air can be Blown into a Balloon or Air Mattress*

Students in class V should have a chance to handle air as a material substance. They need first-hand experiences through which they become increasingly familiar with air and air pressure. One group of such experiences involves inflating objects with air under low pressure. Often this is done simply with the mouth. Here are some such activities:

"Obtain an air mattress if possible, or a large rubber-balloon Permit a student to inflate one of these with air from his lungs. Engage the class in a discussion of how they know air is in the object if the air is invisible, and since ordinary weighing techniques cannot detect it. Help them realize that they know of the presence of the air because of the pressure it exerts on the container. This pressure involves a force which pushes out on the container's walls. Pressure and force are closely related concepts.

As an alternative activity blow soap

bubbles and discuss with students the air which inflates them."

1(b). *Air can be Pumped into the Bladder of a Football or a Tyre.*

A second set of experiments with air pressure concerns objects which are inflated with a pump of some kind. These usually involve pressure much higher than can be developed by the lungs and mouth. Instead, a pump is used—one operated either by hand or by some kind of motor. Because cycle tyre pumps are so common, they provide the means for inflation activities at reasonably high pressure in the classroom.

INVESTIGATION : HOW CAN AIR BE CONTROLLED WITH A PUMP?

"Permit a child to use a cycle tyre pump to inflate either a cycle tyre or a football. Point out to the class that as he operates the pump, he is supplying a force to make the air go into the tyre. The greater the pressure in the tyre, the greater is the force he must use to continue to inflate it. When inflation is complete, invite students to poke tyre or the ball with their fingers, or to sit or stand on it. Help them realize that the pressure inside is able to resist great force from the outside.

As alternative activities, challenge a child to compress air into a bottle with his lungs. The more air he blows in, the greater becomes the pressure.

Or

Take a cycle tyre pump apart and see how it works."

2. *Air Pressure can Move Liquids*

By now students are aware that air, although invisible and often unnoticed, is a real substance. They also realize that air can exert pressure. In the previous major concept, they should have learnt that normal atmospheric pressure—the pressure of ordinary air—is nearly one kilogram of force per square centimeter (1 kgf/cm). They must keep the presence of such normal air pressure in mind to understand this next major concept. The teacher should begin this part of the work by making sure that all students are aware of normal air pressure. If there is any uncertainty about this understanding, it should be cleared up before going any farther.

2 (a) *Air is Removed from a Straw while it is used for Drinking. Normal Air Pressure then Forces the Liquid Up.*

All children have seen people sipping liquids through a straw. Sometimes a real straw—the 'stem' of wheat, for example is used. More commonly, the straw is of paper or of plastic. Children and adults usually describe this process in terms of a person sucking the liquids up through the straw. Actually, such a phrase is misleading. It is much better to think of the liquid as being forced upward through the straw by normal air pressure on the outside. Here are some activities which will help students understand this important point about the way air pressure can move liquids.

INVESTIGATION: HOW CAN LIQUIDS BE SIPPED THROUGH A STRAW?

Invite a student to use a drinking straw to sip some coloured liquid from a container. If possible use a transparent plastic straw. As the class discusses what happens, discourage them from describing the action in terms of 'sucking', or of the liquid being 'pulled up' by a partial vacuum inside the straw. Help them to understand what happens. Point out that the normal air pressure outside the straw is about one kilogram of force per square centimeter (1 kgf/cm). This pressure is exerted on all surfaces, including the surface of the water. If the straw is open at the top, the same pressure is also applied to the surface of the liquid inside the straw. What happens when the demonstrating student starts to sip the liquid through the straw? The pressure inside the liquid is now reduced perhaps to 9/10 kgf/cm. The pressure on the outside is now greater and forces the liquid up the tube. Students may be helped to see how the person sipping the liquid produces a reduced pressure inside the straw. The 'tongue' is like the piston of a simple pump. As the tongue is pulled back, the volume inside the mouth increases. As a result, the molecules are somewhat separated, and there are fewer of them per cubic centimeter. The reduced number of molecules exert a decreased pressure. Help students see that this chain of events is just the opposite of that mentioned in connection with the cycle pump of the preceding major concept. There the volume was decreased and the pressure went up. Here the volume is increased and the pressure goes down.

Invite another student to sip liquid through a paper or plastic straw. While he is doing so, use a straight pin to punch a small hole through the straw between his lips and the surface of the liquid. Observe what happens. Help the class to understand that the pinhole 'leak' in the straw prevents the student from maintaining a reduced pressure inside the straw. As a result, he is unable to lift the liquid to his mouth. Challenge students to see how high they can lift water by sucking through a tube.

Use wax or gum to seal a straw into the top of a bottle completely full of water. Defy a student to suck the water up through the straw.

A Precaution for Designing Simple Experiments in Science

Ved Ratna
Department of Science Education, NCERT, New Delhi

THROUGHOUT the world, now-a-days, there is a movement for simplifying experiments and devising simple apparatus for demonstrating scientific principles to school children. Undoubtedly, such experiments are very valuable in the process of science teaching, because they can be more easily, and therefore more often, shown to children. The simpler and more interesting of these can also be performed by children themselves as a leisure-time activity.

Whereas such experiments are so useful they involve a risk too, which is sometimes difficult to recognize. This risk does not relate to the educational values of such experiments. It relates to a possible carelessness on the part of the teacher who designs the experiment, and it is for this reason that the risk is difficult to recognize.

What is the Risk

In every experiment we make an observation which is the effect of the phenomenon that we want to demonstrate. Usually the effect that we observe can be caused not only by the phenomenon that we want to demonstrate but also by a few other factors, and those factors constitute the sources of error of the experiment. We have to control the conditions of the experiment in such a way, that the desired phenomenon is the major cause, and the unwanted factors are reduced to insignificance. The risk in designing a simplified experiment is that the teacher, in his enthusiasm to simplify the experiment, may lose sight of this principle. Thus the experiment may become such that, although it is very attractive and simple, the desired phenomenon is no more the most prominent cause of the observation to be made in it. It is very essential for the teacher to critically examine the experiment against this risk.

It must be accepted at this point that in simplifying an experiment, the unwanted factors are bound to increase otherwise the refined experiment will be useless, being just as accurate as its simplified version. But if in the simplified experiment, the errors caused by the unwanted factors become comparable to the observation itself, then it must be rejected as being 'invalid.' Let me give two examples of this kind.

Aneroid Barometer

UNESCO Source Book for Science Teaching describes on page 77, a simplified form of aneroid barometer, which children can construct themselves.

"Stretch a piece of thin rubber over the mouth of a small glass jar. Wind thread or string over the rubber to secure it and then put a ring of household

cement under the edges of the rubber sheet which have been trimmed off Cut a thin circle from the end of a cork and glue this to the centre of the rubber Next glue a long broom splint or soda straw to the cork. Cut a little wooden triangle from a match stem and glue to the edge of the bottle so that the splint or soda straw rests on it. A scale can be made and placed behind the end of the splint."

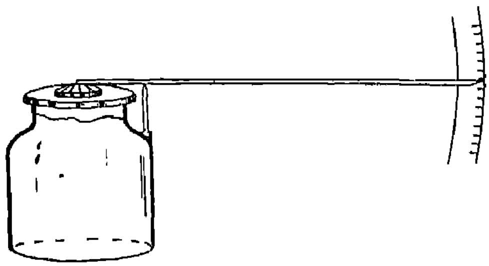


Fig. 1

In this experiment the position of the pointer on the scale depends upon the difference of pressure between inside and outside the jar. If temperature of the room remains constant, this difference of pressure will change as the atmospheric pressure changes, and the pointer will indicate changes in atmospheric pressure. Thus this barometer is quite alright in an air conditioned laboratory or home, but not in a place which is subject to changes in temperature with the time of the day. In Delhi on a calm day the atmospheric pressure may change only by a few mm of mercury from morning to evening, but the room temperature may rise as much as 15 degrees on the Fahrenheit scale, causing a change in the position of the pointer equivalent to a decrease in atmospheric pressure of about 20 mm. of mercury. I have seen (and have felt pity on the innocence of) some students in Delhi constructing this aneroid barometer and very sincerely and regularly taking observations of atmospheric pressure by it extending over a long period of time, the observations being, of course, on an arbitrary scale are not in mm. of mercury.

The most essential features of an aneroid barometer are :

(i) an evacuated box, and
(ii) a spring made of such material that its elasticity changes little by changes in temperature, placed in the box supporting its elastic diaphragm against the atmospheric pressure and thus measuring the atmospheric pressure much as a spring balance measures the weight of a body.

If these features are neglected in any demonstration or model of the aneroid barometer, it is likely to cause misunderstanding.

Elasticity of Air

In a TV-lesson on Boyles' Law the following experiment was shown to draw the conclusion that 'air is elastic.'

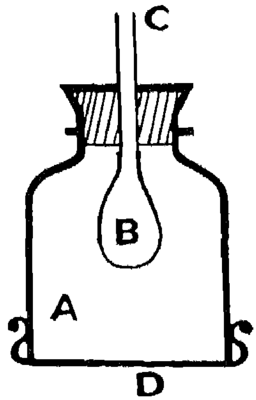


Fig. 2

A rubber diaphragm D is tied at the bottom of a belljar. Inside it is a toy balloon B attached to the lower end of a tube C. The tube is fixed by a rubber cork in the mouth of the belljar. Thus air can freely go in or come out of space inside the balloon, but space A (inside the belljar and outside the toy balloon) is a closed space. When the diaphragm is pushed in, the balloon collapses and some of the air in it comes out. When the diaphragm is released, it comes back to its original position, and the balloon also regains its original volume.

It was argued that, when the diaphragm is pushed in, air in the belljar is compressed. Thus its pressure increases, and due to this increased pressure, air inside the balloon is driven out. This shows that air is elastic.

But the following points are noteworthy in regard to this demonstration and this argument:

(i) Any increase in the pressure of air in space A is only transient and exists only during the inward motion of the diaphragm.

(ii) Even the transient increase in the pressure of air in space A will be very small, because the inertia of air in space B, as well as of the walls of the balloon, is very little. Thus transient decrease in the volume of air in space A will be very small compared to the observed collapse of the balloon *i.e.*, the observed decrease in volume of balloon.

It may be better in this demonstration that the mouth of the tube C be kept closed when the diaphragm is pushed in. Thus air in space A as well as in balloon will be compressed, and compression of air in the balloon will be observed as a slight collapse of the balloon. Thereafter, the mouth of the tube C be opened, and the balloon will further collapse showing that air in the space A had also been compressed.

Measuring Time-period of a Pendulum

It would be appropriate here to mention also an example of over-simplification sometimes done by science teachers. Recently I had the chance of observing the practical work in physics of the students of a few schools in Delhi. I was surprised to find that students measured the time period of a pendulum by starting and stopping the stop-watch when the bob is at one of its extremeties A or B (figure 3). Let us call it method 1.

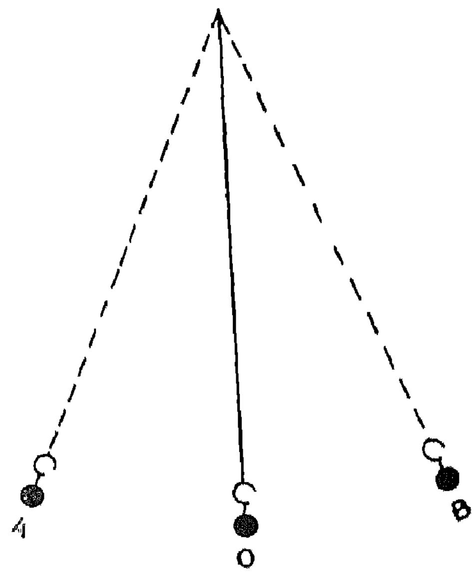


Fig. 3

For the accuracy of observations I prefer the method that the mean position O of the bob be marked, and the stop-watch be started and stopped when the bob passes through O in a previously thought-out direction, either A to B or B to A. Let us call it method 2.

When I asked the teachers about it, they all preferred method 1 saying that students commit mistakes of half an oscillation in counting oscillations if they use method 2. As regards the accuracy of observations, they considered both methods equally good.

I asked one of them, 'which method will you prefer for measuring the time period of a Torsion Balance, which may be of the order of 2 or 3 minutes?' He then understood my argument that method 1 is not accurate because the bob is momentarily at rest in positions A or B, and changed his opinion in favour of method 2.

It can be agreed, of course, that when we are using a stop-watch both the methods are equally accurate for measuring a time period which is of the order of 2 or 3 seconds, as in the case of a pendulum. But still method 1 should not be preferred, because the students should grasp that method 2 is the proper method of measuring the time period of an oscillating body.

Conclusion

While designing any simple experiment, it is important that extreme care be exercised against the unwanted factors that influence the observation. By the slightest carelessness errors can increase so much as to invalidate the experiment. This situation can arise even in experiments described in books written by famous authorities in their subjects. The only authority acceptable in this regard is logic.

In India, as we cannot equip our school laboratories with much sophisticated equipment, the ingenuity of science teachers in designing simple experiments is a great factor in improving our standards of science teaching. Thus the above mentioned precaution in designing simple experiments is of particular importance for science teachers in India.

Science Abroad

New Understanding of the Link From Ear to Brain

Brian Maskell

THE tools of rapidly-advancing technologies are now being put to work on some of the most formidable research projects—those associated with studies of senses and control systems in living things.

At the Neurocommunications Research Unit of the Birmingham Medical School, research is being conducted into the hearing system, under the direction of Dr. I.C. Whitfield.

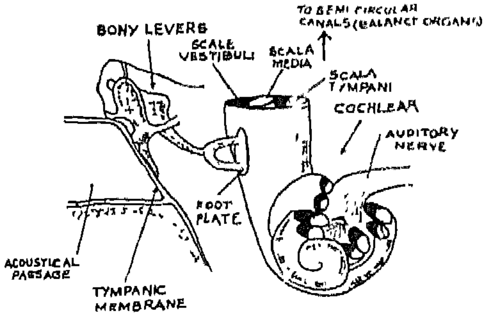


Figure 1. An illustration of the human ear mechanism. Sound waves arriving *via* the acoustical passage cause the tympanic membrane to vibrate. A hinged bony structure carries these vibrations to the cochlear mechanism.

While the anatomy of the ear is fairly well established, (Figure 1) a detailed understanding of its way to the brain, and how it is recognized in the brain's auditory section has until recently, remained largely a matter for conjecture.

Sound pressure waves arriving *via* the acoustical passage cause the tympanic membrane to vibrate: the vibrations are transferred *via* a system of bony levers to the wall of an organ known as the cochlea. This consists of a tube which is divided into three sections by two partitioning membranes — the reissner and the basilar (Figure 2). All three sections are filled with a body fluid, although the chemical composition of the fluid in each section is slightly different.

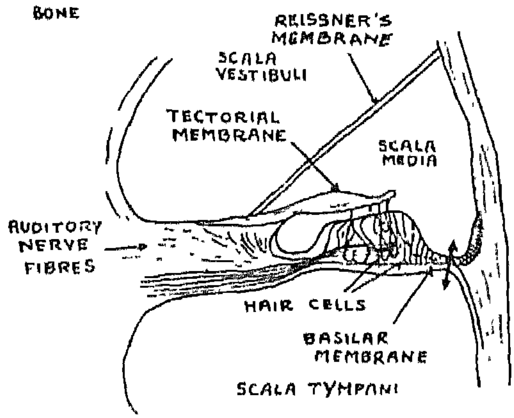


Figure 2. A sectional view of the cochlear transducer mechanism. Vibrations from the bony structure make the tectorial membrane vibrate as well, causing movement of the hair cells. These stresses eventually fire electrical impulses to the brain *via* the nerve fibres.

Reissner's membrane serves merely as a partition between different fluids, but the basilar membrane is also the key

Reprinted from SPECTRUM **14:** 10-11 July 1965

structure of the ear since it carries the transducer mechanism which converts one form of energy into another. This mechanism comprises a number of hair cells from which hairs protrude.

Another membrane (the tectorial membrane) lies over these hairs. When sound waves produce vibration in the fluid-filled sections of the cochlea, the basilar membrane moves up and down in relative motion, causing a shearing action between the tectorial and basilar membranes. This action is similar to flexing a paper-back book, back and forth, the covers representing the two membranes.

The hair are quite stiff and apparently transfer the shearing stress to the plate-like surface of the hair cells on which they are fixed. The result of this stress is to produce a change of electrical potential across the hair-cell surfaces, so this change of potential represents the mechanical vibration. The system is to some extent similar to the operation of a microphone.

One important fact has been discovered about the energy of the electrical potential—it is greater than the energy of the mechanical vibration, indicating that incoming vibrations control an existing source of electrical energy. This is something like the operation of a transistor or thermionic valve, except that these devices amplify small electrical changes into larger replicas, whereas the ear is a device which translates a mechanical input directly into an amplified electrical output.

Associated with each of the hair cells is one or more nerve fibres (Figure 2.). They group together to form the auditory nerve trunk (Figure 1) which contains about 40,000 of these fibres. Activating the nerve cell in some way triggers off electrical impulses in the associated nerve fibres. High amplitude vibrations of the basilar membrane cause a similarly high rate of impulses fired along a nerve fibre.

The basilar membrane is about 35 millimetres long and varies in width from 0.04 mm. at the base of the cochlea to 0.50 mm. at its apex. Furthermore, the stiffness of the membrane changes progressively from one end to the other.

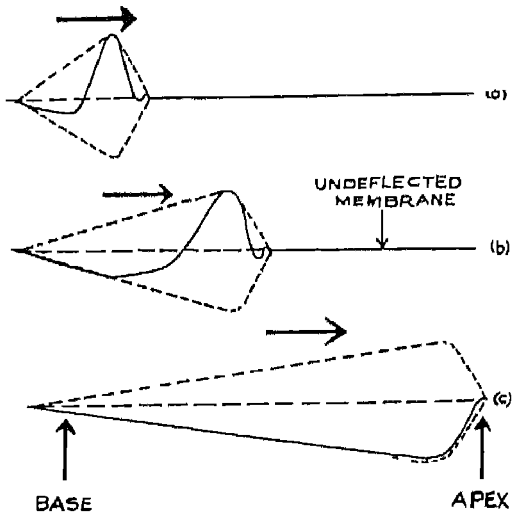


Figure 3. An illustration of the 'travelling wave' nature of the basilar membrane movements when responding to (a) high frequencies, (b) medium frequencies, and (c) low frequencies.

The effect of these changes is that vibrations induced by the fluid occur as travelling waves (Figure 3) which pass along the membranes from base to apex. They reach their highest amplitude at some point and then die away rather rapidly. At high frequencies (10 kilocycles per second) this point is quite

near the base, whereas at low frequencies (100c/s) the waves travel right to the apex before dying out.

As there are nerve fibres along the whole length of the basilar membrane, the brain can tell how much of the membrane is vibrating—so it can tell the frequency of the stimulus. The louder the stimulus, the greater will be the movements of the basilar membrane, and the faster will be the pulse firing rate of the section of fibres concerned.

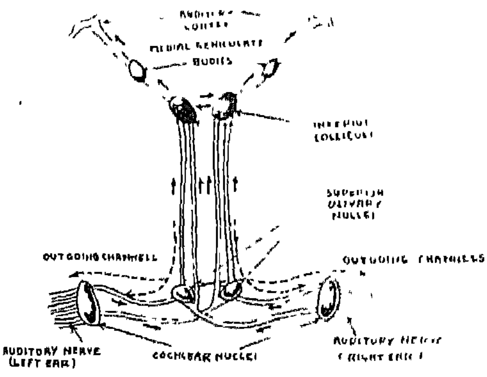


Figure 4. The routing of auditory information to the brain cortex.

The auditory trunk nerves leaving the areas of the right and left cochlea each terminate in an organ at the base of the brain. This is called the cochlear nucleus (Figure 4), and it processes the information coming in from the cochlea before passing it on to a maze of interconnections with other centres. Eventually the information finds its way to the auditory cortex of the brain.

The pattern of the input to the cochlear nucleus which results from a single tone stimulus is shown in figure 5a. Each vertical line corresponds to about 10 to 20 fibres; each thin line cor-

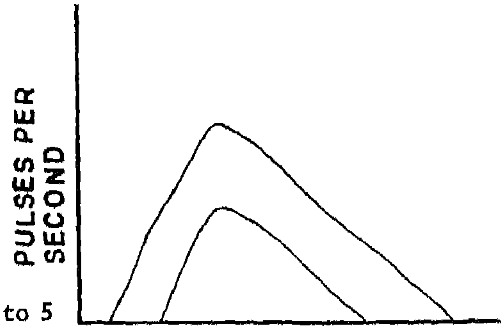


Figure 5a. Pattern of nerve activity in the auditory nerve in response to a tone stimulus. The horizontal axis represents part of the total array of nerve fibres in the auditory trunk nerve. Each upright line represents about 10 to 20 fibres and its height represents the average rate of pulse activity in that group Heavy lines represent the response to a weak stimulus, and the thin lines the response to a louder tone

responds to a strong stimulus, each thick one to a weak stimulus.

Output from the cochlear nucleus is shown in figure 5b. It will be seen that the pulse firing rate has been reduced, but most significant is the 'averaging' which has taken place. If an

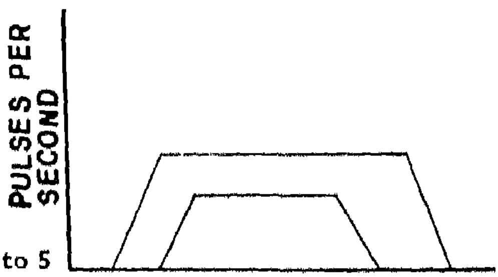


Figure 5b. The pattern of activity after cochlear processing. Maximum pulse rates are lower and there is less difference in the pulse rate for the same change in intensity

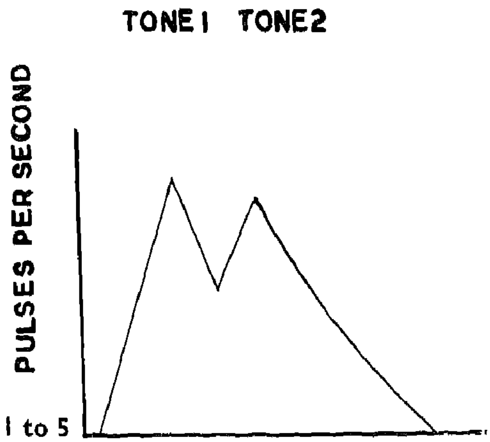


Figure 6a. Input received by the cochlear nucleus as a result of two separate tones.

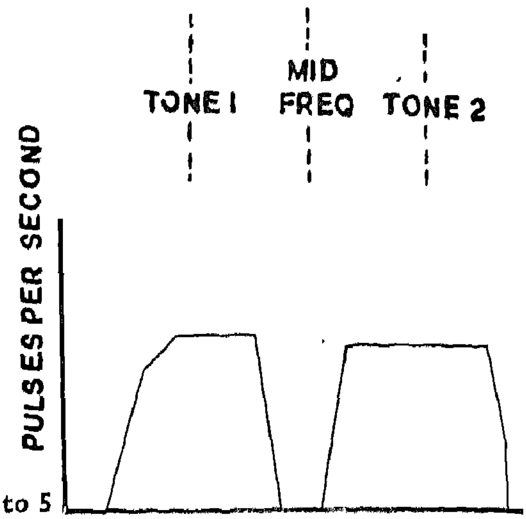


Figure 6b. Output beyond the cochlear nucleus showing the effect of inhibition in separating the responses.

incoming nerve fibre is firing above a very slow rate—in other words above a 'threshold'—its corresponding output fibre is made to fire at a fixed level.

Likewise, input fibres firing at a fast rate have corresponding output fibres whose rates are reduced to the fixed rate. Where the fibres are firing reveals the pitch of the sound; how many of them are firing, shows its intensity.

The Birmingham team has also been looking at the way in which the auditory system discriminates between two adjacent tones. Figure 6a shows the pattern of a two tone input to the cochlear nucleus, and figure 6b shows the corresponding output pattern. The very sharp and well-defined dip in figure 6b occurs because the input fibres between the two frequencies are not firing quickly enough to qualify for upgrading to the fixed level

Recent discoveries at Birmingham concern certain nerve cells in the auditory cortex (outside part of the brain). It appears that one of these cells responds either to a falling tone or to a rising tone; not to both

At nearly all stages of processing there are fibres carrying information back in the direction of the cochlea (shown by the dotted lines in figure 4). These 'feed-back' fibres are not yet understood in detail, but their function appears to be to decrease the input. They may do this over the whole range of stimuli (volume control) or act only to suppress certain irrelevant and therefore unwanted signals.

The fact that one is inclined to be unaware of the ticking of one's sitting room clock until it stops, is perhaps an example of this.

All-Seeing Eye Searches the Universe

A. Huguenot Van Der Linden

SINCE the end of World War II, a completely new branch of astronomy has come into being: radio astronomy. With the aid of giant concave metal mirrors, the weak 'mush' of radio signals emanating from the universe are picked up, amplified and turned into a visible form on a chart. You could almost describe this as 'charting the invisible part of the universe'. Dutch scientists have scored some notable successes in this new and fascinating sphere.

If you were to make a tour of the province of Drenthe in the North of Holland, you would eventually come across an area of open ground not far from the village of Dwingeloo on which stands a metal colossus. At first sight it resembles one of those strange pieces of modern sculpture executed in steel rod and wire...except, perhaps, that it is as high as an eight-storey block of flats. It completely dwarfs the sheep which peacefully graze around its foundations. This strange man-made giant is busy listening to the strange heavenly music which reaches us from the universe: it is a radio telescope and its task is to pick up mysterious radio waves from far out in space and provide the astronomers with material from which to draw conclusions. On the front of the apparatus is a huge concave 'mirror' made from wire mesh. it doesn't shine like a normal mirror but that doesn't matter because radio waves coming from space are reflected off it just as powerfully as light rays off a normal mirror. This mesh mirror rotates on a horizontal shaft mounted in a high tower; this in turn, is mounted on four bogies running on a circular rail track. This combination allows the whole apparatus to turn on its own axis while at the same time the mirror can be swung up and down and can be pointed at any spot in the heavens (provided, of course, this is above the horizon). The radio telescope is not, as you might imagine, only used at night; the universe provides listening material enough during the daytime also. The stars may not be visible owing to the sunlight, but the emission of radio signals goes on unabated.

In the centre of the mesh mirror is a long probe, at the extremity of which a dipole antenna is fitted. This is mounted precisely in the focal point of the mirror. Signals reaching the mirror are concentrated at the focal point where they are absorbed by the antenna and fed to a receiver. Just as your radio receiver at home amplifies the signals fed to it, so does the receiver of the radio telescope amplify the signals fed *via* its antenna; but the process is considerably more complicated and the degree of amplification thousand times as great. The amplified signals have sufficient power to operate a pen under which passes a continuous roll of graph paper. Seen on paper, these 'sounds from outer space' are merely lines going up or down in relation to the centre

By Courtesy: the Royal Netherlands Embassy, New Delhi.

of the roll, the significance lies in the fact that modern techniques have made part of the invisible universe visible to the human eye. The radio telescope at Dwingeloo was officially opened by Her Majesty Queen Juliana of the Netherlands on 17 April 1956, in the presence of the world's leading astronomers. Until recently it was the largest and most refined instrument of its type in the world and the numerous and highly important discoveries made with its aid have given Dutch scientists a considerable lead in this fascinating new field of research. In terms of sheer size, however, the instrument has now been overshadowed by the radio telescope at Sydney in Australia, and by the giant instrument at Jodrell Bank near Manchester in England, of which the famous astronomer Sir Bernard Lovell is in charge. The mirror of the Jodrell Bank telescope is so large that gun mountings of battleship dimensions were needed to support it. In fact the mountings from the sunken H.M.S. *Royal Sovereign* were salvaged and put into use again. The Jodrell Bank telescope has become particularly well known in lay circles, thanks to the role which it has played in tracking American and Russian space craft. Soon, however, even this giant apparatus will be dwarfed by one being built by the United States Navy in a deserted valley in the state of West Virginia. This 'giant of giants' will have a mirror something like 600 feet in diameter—large enough to contain a football ground with stand and terraces. The West Virginia radio telescope will be about 660 feet high—and that's equal to a 66-storey block of flats. Apart from topping the list of radio telescopes it will be the largest scientific instrument in history. Placed alongside these two, the Dwingeloo telescope assumes somewhat modest proportions. But with it, Dutch astronomers, carrying on the tradition of their country, have achieved wonderful results. Among these was the charting of the very first system of 'streets and squares', as they might be called, in the Milky Way. This they did with only the information drawn from the extremely weak signal pattern picked up with their huge 'metal ear'. Radio astronomy is a relatively new science, but it has donned the seven league boots of a giant in striding forward since the end of the last war.

It all began when a young American engineer named Karl Jansky was given the job of finding out the source of mysterious radio signals which were causing a lot of trouble in trans-atlantic radio-telephone communication. That was in 1932. At that time no one dreamed that the source of the interference might lie in the universe, but Jansky observed that the whistles, hisses and other sounds which reached his headphones commenced four minutes earlier each evening and always came from the same direction. This could only indicate that the sounds came from outer space since the pattern of the earth's annual rotation around the sun is such that the stars 'rise' four minutes earlier every evening.

Jansky's discovery was a momentous one but, as so often happens, no one displayed much interest at the beginning. Jansky died in 1950, just when radio astronomy was about to take its

greatest leap forward. He did find one disciple, a fellow countryman named Grote Reber. Using primitive equipment, Reber built the first radio telescope near the bungalow in which he lived. This had a mirror of only 30 feet or so in diameter but even so its designer was able to pinpoint the source of a number of radiations including those from the constellations Eagle and Swan. That was in 1940 and although the ensuing five war-years practically brought the new science to a halt, its significance was realized by experts because of the influence which the distant emissions had on the military radar observations by the allies. Towards the end of the war, a number of half-starved astronomers braved the continuing Nazi occupation and the acute shortage of food and organized a meeting of the 'astronomers club' to hear a lecture by a young and unknown student by the name of Hendrik Christophe Van de Hulst. Although only 22 years of age, he spoke fervently of his belief that the so-called neutral hydrogen gas which is present in large quantities in between the stellar constellations radiated waves on a frequency of 21 centimetres. So convincing was Van de Hulst's argument that his tutor, Jan Hendrik Oort of the centuries-old observatory in Leyden, immediately grasped the significance of it. Professor Oort, who has received numerous high scientific awards (and who has been described in the United States as one of the ten leading scientists of his time) set about establishing the 'Solar and Milky Way Radio Emission Foundation' and making preparations for the building, as soon as hostilities ceased, of a radio telescope in which Van de Hulst's theories could be put to test.

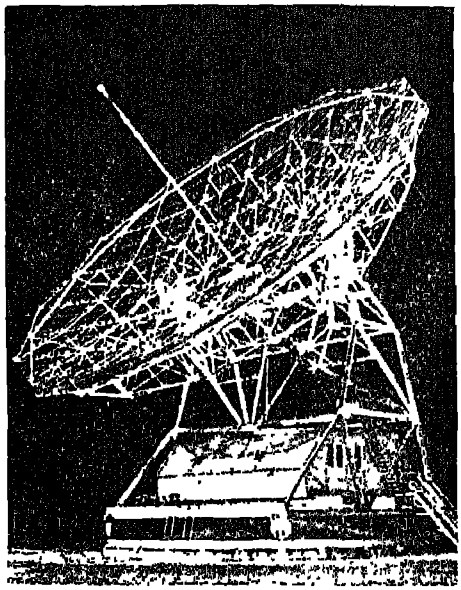
Professor Hendrik C. Van de Hulst

In due course they set to work feverishly to re-erect an old German radar reflector on an open space at Koot-wijk. But they were to suffer a setback. In March 1950 — less than five years after the end of the war—the costly instruments which were to amplify and make visible those extremely weak signals from space were destroyed by fire, and by the time the complicated apparatus had been rebuilt, a group of American radio astronomers at Harvard Observatory had stolen a march on the Dutch and their theory of the hydrogen emission. That was in the Spring of 1951. A few weeks later, the Dutch engineer C. A. Muller succeeded in confirming

their discovery, but Van de Hulst received full credit for his ingenious predictions. In the meantime Van de Hulst had become a professor and among the rewards which were heaped upon him was a high decoration from the National Academy of Science in the United States. Later, he was elected president of COSPAR, the international committee of experts charged with the task of making recommendations for space research projects.

Why was Van de Hulst's discovery so important? A simple example will suffice to answer that question. If you stand at a point somewhere along a highway where cars are passing at high speed you will notice that, if a driver sounds a continuous note on his horn, the note of the horn gets higher and higher until the car passes you. Once past, the note drops suddenly. This is the so-called 'Doppler effect', and from the shift in tone, the speed of the vehicle can be calculated with suitable instruments.

Van de Hulst came to the conclusion that 21 centimetre wave length signals emitted by the hydrogen gas mass might well create just such an effect and that, in turn, the speed of the hydrogen atoms moving through the Milky Way could be calculated in a similar manner. From this, scientists could deduce the composition of the Milky Way. As we have said, the theory of Van de Hulst was accepted and the 21 centimetre line has become a basis of astronomers in various parts of the world. But what are the most important discoveries which have been made with the aid of the radio telescope at Dwingeloo? Firstly it has provided positive evidence that the Milky Way (of which the earth is a part) consists of a cluster of about 100,000 million stars similar to the Sun. Actually this is not a cluster as such because the stars which go to make this up are many light years apart. But if we keep to our giant yardstick of the universe, the reference to a cluster is justified. Around the central cluster lie



The 'big dish' at Dwingeloo

a number of flat spiral arms reminiscent of a watchspring. This comparison can be taken a step farther if we imagine that such a spring were lightly greased and icing sugar sprinkled on it; every minute grain of sugar would represent a solar body similar to the Sun. This would, in fact, be found on one of the outer coils of the spring and surrounded by an insignificant wreath of invisible dark planets of which the Earth is one. Significant as this discovery may be, it was not the be all and end all. The scientists at Dwingeloo

also established by clouds of exceptionally rarefied hydrogen gas which, together with the entire stellar system, revolve around a common axis. Finally it was discovered that the gaseous mass in the nucleus of the Milky Way was being dispersed with enormous velocity, probably as a result of magnetic forces. This last discovery came as a complete surprise and created a terrific impression on the entire international scientific world when it was disclosed at a gathering of the Royal Netherlands Academy of Sciences, held on 29 November 1958 in one of the magnificent Patrician houses flanking the Amsterdam canals. Even now the extent of the discovery cannot be measured, but it will always remain coupled to the name of two Dutch scientists, Prof. Oort and the astronomer G. W. Rougoor

At present the radio astronomers know of three main sources of radio emission. These are the sun, the gaseous masses which hurtle around in the space in between the stars and, lastly, the so-called point sources of which some 2,000 have so far been discovered. This term means simply that there is a point or small region in the heavens from which strong signals are emitted; so far the real significance of these has only been ascertained in 60 or 70 cases. The remainder are still a complete mystery. One of the point sources which has been identified proved to lie in the constellation Cygnus A. Investigations showed that a gigantic cosmic catastrophe had taken place in that constellation the like of which goes completely beyond human comprehension. Two vast stellar worlds—spiral nucleii like our Milky Way and each consisting of hundreds of millions of solar bodies—attacked each other, as it were. They tore across each other's paths with the result that the gaseous atoms in them collided with such terrific force that they became sources of radiation. All this took place so far away in space that the radio waves produced took 270 million years to reach the earth. Multiply this by their speed of 186,000 miles per second and you will have an idea just how far out in space all this happened.

Naturally not all the major discoveries in the field of radio astronomy have fallen to Dutch scientists. Astronomers in Australia, England, the United States and many other countries have made valuable contributions. At the same time, the pioneering work done in Holland has proved to be of such significance that, small as this country may be, it may proudly stand alongside the larger nations in the field of radio astronomy. This applies in particular as professor Oort is now directing a Leyden university team of scientists of several nationalities, whose objective is the construction of an enormous Benelux radio telescope, fitted with a giant ross-antenna. This instrument will consist of no less than 103 movable parabolic mirrors of a simplified Dwingeloo type, each of them measuring 90 feet across and arrayed along two arms at right angles and covering many square miles in the frontier zone between Belgium and the Netherlands. Construction will be completed in 1967, providing Europe with the largest and most sensitive instrument of its kind in the world.

Young Folks Corner

Homi Jehangir Bhabha

R. N. Rai

Department of Science Education, NCERT, New Delhi

DR. Homi Jehangir Bhabha, whose premature death on 24 January 1966 in an air crash resulted in a grievous loss to science, was born in Bombay on 30 October 1909. He was educated in the Cathedral and John Connon High School, Bombay and later at the Elphinston College and the Institute of Science, Bombay. At the early age of 17 he proceeded to Cambridge for higher studies where he joined the Gonville and Caius College and in 1930 passed the Tripos in Mechanical Science. He studied theoretical physics for two years under the supervision of Prof. Dirac and Prof. Mott of Cambridge.

He was awarded the Rouse Ball Travelling Studentship in Mathematics of Trinity College, Cambridge from 1932 to 1934 which he utilized in working with Wolfgang Pauli at Zurich, Enrico Fermi at Rome and for a brief period with H.A. Kramers at Utrecht in Holland. In 1935 he was awarded the Isaac Newton Studentship and in 1939 appointed as a theoretical Physicist in Prof. Blackett's laboratory at Manchester. He was appointed a Reader in theoretical physics at the Indian Institute of Science, Bangalore and was professor from 1942 to 1945 when he founded the Tata Institute of Fundamental Research in Bombay.

Dr. Bhabha's main work concerns cosmic rays and elementary particles. Cosmic rays are from the outer space. In the atmosphere, they produce secondary particles which cause ionization and thus their path can be observed in Wilson cloud chambers The secondary radiation consists of two parts. One the soft component and the other the hard component. The soft component consists of electrons, positrons and X-rays which are easily absorbed by matter. During their absorption some of the very high energy electrons and photons give rise to a large number of particles whose paths become visible in cloud chambers and these are known as cascade showers. Bhabha and Heilter and simultaneously Carlson and Oppenheimer explained these showers as arising from the absorption of high energy electrons and photons. A shower is usually initiated by an electron of energy of many billions of electron volts. It emits a photon of camparable energy by a process known as brems-strahlung. These photons are absorbed and produce an electron-positron pair which then produce more photons by the same process. This goes on until a large number of electrons and positrons have been produced and the energy of each particle is comparatively low This

Homi Jehangir Bhabha 1909-1966

theory gave an impetus to the study of showers and led to the discovery of extensive air showers and explained the fact that the intensity of cosmic rays passed through a maximum at a pressure of about 70 mm. After his return to India, Bhabha continued to be interested in this problem and in collaboration with S.K. Chakrabarty published a paper on the average number of secondaries produced by a primary of given energy.

Other problems studied by Bhabha were the scattering of positrons by electrons and that of mesons by nucleon. To understand the electron-positron scattering, we must remember that according to Dirac's theory the positron is a hole created by lifting an electron from a negative energy state to one of positive energy. Therefore in the scattering of positrons by electrons two processes can take place. In the first process the electron is lifted from its original state to state of higher energy by an amount E and the hole (which appears to us as a positive electron) is filled by a negative energy electron E units above the original hole, thus creating a hole or positron of less kinetic energy. In the second process the electron falls into the hole and the

energy difference is used in lifting a negative energy election to a positive energy state, thus creating a hole or positron. Bhabha's theoretical calculations have been experimentally verified and provide a test for the hole theory.

The scattering of mesons by nucleons is similar to the scattering of light by electric charge, the only difference being that the scattering cross-section depends on the mass of the meson and not on the mass of the nucleon.

Dr. Bhabha will be best remembered for his efforts in developing atomic energy in India. An Atomic Energy Commission was established in India in August 1948 and in 1954 a separate Ministry, the Department of Atomic Energy, was set up under the Prime Minister with Dr. Bhabha as its secretary and under his leadership the country made a significant advance in the development of atomic energy for peaceful purposes.

Before a programme for the generation of energy from nuclear fission can be undertaken, it is necessary to combine the experience of the various processes involved by working with a research reactor. Therefore the Department of Atomic Energy began the construction of a research reactor called *Apsara* in July 1955 with help from the United Kingdom Atomic Energy Authority. This reached criticality on 4 August 1956. Later two more research reactors were built; one the Canada-India Reactor with Canadian help and the other the *Zerlina* which was designed and built entirely by Indian personnel.

It had been decided in 1954 to embark upon an atomic power programme, and in 1958 the Planning Commission approved the setting up of an atomic power plant during the Third Plan period. Later in 1962, the Government decided to set up a second atomic power plant during the Third Plan. It is expected that the first power plant located at Tarapur, 60 miles north of Bombay, which is using ordinary water as moderator and coolant and enriched uranium as fuel, will be producing power by October 1968. The second atomic power station located near the Rana Pratap Sagar Dam, which will use heavy water as moderator and coolant and ordinary uranium as fuel, is expected to be in operation in 1969. A plant for producing 14.5 metric tonnes of heavy water per annum is already working at Nangal in the Punjab and it is proposed to set up a plant with a capacity of 200 tonnes per annum.

As is well known, the generation of nuclear power depends on the fission of an isotope of uranium of mass number 235. This isotope is only 0.7 per cent of natural uranium. However, the other isotope of mass number 238 can be converted in a nuclear reactor into another element plutonium which is also fissionable. A vigorous search was undertaken by the Department of Atomic Energy to locate useful deposits of uranium and considerable reserves of uranium have been located in Bihar. A uranium mill for processing 1000 tonnes of ore a day is being built at Jaduguda in Bihar which is expected to begin production in the later half of 1966. When in full production this mill will produce

200 tonnes of uranium oxide per annum which will be enough to sustain a generation of about 10 million kw of nuclear power. According to present estimates this rate of production of nuclear power will be reached about the year 1981.

The plutonium that is formed in a nuclear reactor has to be separated from the uranium and the fission products. A plant to extract plutonium has already been completed at Trombay and is in operation. This will be used to extract plutonium from the irradiated rods of the Tarapur station and recover the enriched uranium thereby reducing the import of enriched uranium from USA.

However, India does not possess very large deposits of uranium. On the other hand it possesses large deposits of thorium of mass number 232 which can be converted into uranium of mass number 235 which is fissionable. It is proposed to use plutonium to do this and the Department of Atomic Energy has decided to build a breeder reactor at Kalpakkam near Madras where the third nuclear power station is to be built.

Although the generation of nuclear power in India is small in comparison with UK where 5 million kw of nuclear power is to be produced by 1975, India occupies an important position on the nuclear map due to the foresight of Dr. Bhabha and his death at this juncture is a great loss to the country.

Prof. P. Maheshwari

PROF. P. MAHESHWARI FRS
1904-1966

SCHOOL SCIENCE takes the first opportunity to express its deep sense of loss and regret at the passing away of Prof. P. Maheshwari on 19 May 1966. The time when we felicitated him on his election as a Fellow of the Royal Society of London, little more than a year ago, is still fresh in our memory.

Prof. Maheshwari joined Delhi University as professor when it started the Botany Department in 1949. In 16 years he brought this Department to an eminence as an Advance Centre of Research in Plant Morphology and Experimental Embryology. He built up a fine team of workers who have already made a large contribution in this field. It must be said to the credit of the late Professor that though his loss is very great, the group of workers he trained and left behind will be able to take his work forward from where he left it. Some institutions are great in themselves and many eminent men of science achieve individual fame and name because of their association with the institution; but some institutes are made big because of the efforts of a single person. The Department of Botany of the Delhi University is example of an institution which grew to eminence because of the ceaseless efforts of one man. During Professor Maheshwari's lifetime, his presence could be felt in every corner of his Department.

Prof. Maheshwari had an international reputation as a leading Plant Morphologist. He was a source of inspiration to many research workers in the country who sought his help freely. He founded the International Society of Plant Morphologists of which he was elected the first President. He used to watch with interest the work of every Indian research worker in botany both within the country and abroad. He encouraged all research workers by voluntarily giving them help in their work. We had occasion to refer to his work when we felicitated him in an earlier issue of SCHOOL SCIENCE (see Volume 4, No. 2, June 1965).

The National Council of Educational Research and Training is grateful to Prof. Maheshwari for his valuable contribution to many of its ventures in the field of Science Education. The textbook on Biology developed by the Biology Textbook Panel, of which he was the Chairman, has now been completed and is already in use in many schools. In the death of Prof. Maheshwari, India has lost an eminent botanist at the peak of his career and while he was still very active and energetic. His loss is shared by all scientists in this country. May his life-work and career serve as a source of inspiration to many future botanists who are now students in schools.

Test Your Knowledge

What is the Physics of Body Temperature Control?

Molecules of water at the skin's surface move apart to form water vapour i.e., water evaporates. This is a heat-lowering process: because when a high-speed (one with greater kinetic energy) molecule is lost by evaporation, its energy is subtracted from the total energy of the liquid and the net temperature is consequently lowered a little; there are fewer collisions between molecules left behind. The right body temperature is maintained by regulating the amount of liquid present for evaporation. The 'thermostat' which sees to this is the thalamus gland, located at the centre of the brain.

What is a Virus?

Viruses are single giant molecules with the peculiar ability of reproducing themselves with the aid of cells which harbor them. They lie on the border line between 'dead' chemical substances and the lowest form of life. They hold some of the secrets of life itself. Many viruses are responsible for diseases that cannot yet be cured.

Do Viruses Cause Disease by Producing Toxins?

Apparently not. They simply interfere so badly with the running of the normal chemical household and by robbing it of its supplies that break-down occurs.

Does the Body Defend itself from Virus Attack as it does from Bacteria?

It tries to but the supposition is that the virus is much harder to overcome, since it is not an organism of cells and hence does not have true metabolism that can be upset. The body tries out many antibodies and in many cases succeeds. In others *e.g.*, meningitis, the antibodies nearly always fail to work.

What is the Approach to Combating Viruses?

A chemical one. Biochemists are working hard toward analyzing exactly what constitutes each virus chemically especially what configuration the offending molecules have. It is hoped that in this way weak spots of molecular structure will be found. Substitution at these places will abort the growth and subdivision of the virus. But the agents (used for substitution) must not be able to damage the normal body cells.

What is Fool's Gold?

Three minerals may on occasion so much resemble gold that they have long been known as fool's gold. These are: pyrite, chalcopyrite and biotite mica. (weathered biotite mica looks astonishingly like flake gold).

What is a Desert Rose?

Not a flower at all but a mineral having a rosette form like that of a flower with its petals opened. It is usually composed of quartz or gypsum,

though it may be some other mineral as well.

What is a Magnetic Memory Device?

The magnetic memory device is a small highly magnetic metal drum which receives and stores up readings from the various instruments inside the satellite. When the radio transmitter in the satellite is triggered by an electric impulse sent out from radio station upon the Earth, the information stored upon the magnetic drum is sent back through the satellites transmitter and the drum is cleared ready to accumulate a new set of data.

Science Notes

*INTERNATIONAL CONFERENCE ON NUCLEAR FUSION PROBLEMS

A FIVE-DAY conference on plasma physics and controlled nuclear fusion research will open on 6 September at the United Kingdom Atomic Energy Authority's laboratory at Culham, southern England.

The conference will discuss the latest developments in attempts to harness nuclear fusion. Two hundred and seventy-five delegates from 25 countries will be attending the conference.

Culham is the site of British work on fusion problems. The research is aimed at controlling the release of energy from the fusion of light nuclei, especially those of deuterium (or heavy hydrogen) which can be extracted from sea water.

Temperatures of 100,000,000°C. or more are required to sustain a reaction in the plasma or hot gas, and magnetic 'cages' are needed to contain the wriggling matter.

So far, there has been no success in holding plasma of the right density at the right temperature for a long enough time to produce fusion. But the prize is so glittering that research perseveres all over the world.

MICROSCOPE CAN SEE SIDES OF ATOMS IN METALS

A new microscope which enables research workers to look for the first time at the sides of the individual atoms in metals is now being produced by a company in Britain.

The result of five years' work by a group of three Cambridge research workers, the field ion microscope was shown at the recent 1965 Physics Exhibition in Manchester. The prototype was completed in six weeks from drawings by Dr. Brian Ralph of the Department of Metallurgy, University of Cambridge.

Compared with the electron microscope, which has a magnification of 250,000 times, the field ion microscope's magnification is, on average, about 1,000,000 times—though it can be much higher.

By using other techniques, individual atoms or atomic layers can be stripped from the surface of the specimen and other factors can then be studied—such things as damage caused by radiation, or the boundaries between grains of metals.

Although the microscope could until recently only be used with refractory metals and alloys, it has now been used to study iron and nickel. Metals are not the only materials suitable, however. Graphite and silicon can also be examined.

The field ion microscope will have applications including the aircraft industry on such projects as the Concord, and the nuclear power industry.

*By Courtesy British Information Service, New Delhi.

SOLVING COSMIC RAY PUZZLE

Cosmic ray recording stations will soon be spread across 50 square miles of country in a deserted area of the north-west of the State of New South Wales, Australia, in a research project to try to find the origin of cosmic rays and to measure their energy.

The University of Sydney which is linked with Cornell University, New York, in the world's biggest radio-astronomy and cosmic ray research organization, is planning the array. When complete, this cosmic ray research system will be the largest of its type in the world.

Eventually, an array of aerials will dot the countryside round the town of Narrabri, already well known in world scientific circles because of the stellar intensity interferometer built there in 1960 to measure the angular diameter of stars.

Buried in the ground at each station will be the recording equipment—two big liquid scientillators to detect the particles from the high energy nuclear interactions in the atmosphere.

This equipment is so sensitive that it can measure a tenth of a millionth of a second. Its purpose is to measure the number of cosmic particles which hit the earth, as well as the intensity and power with which they strike the surface.

The scientists hope the research will throw much light on the nature of the universe, one of the most puzzling scientific questions in the world today.

AUSTRALIA SEEKS MORE QUASARS

Quasars are very distant objects which shine brighter than a-hundred-million stars. They have attracted great scientific interest because the source of their enormous energy output is not yet understood.

Quasar 0106+01 is so far out in space that the light and radio waves received from it have been travelling for a time greater than three times the age of the earth and sun.

Mr. John Bolton got the first firm 'fix' on Quasar 0106+01 on 13 August 1964. Later investigation at the Mount Palomar and Lick Observatories in the United States confirmed his suspicion that it was a quasar.

Its discovery was announced at a scientific conference in Miami, US, in December 1965.

With scientific circles still stimulated by the recent Australian discovery of quasar 0106+01—receding into space at a speed of more than 120,000 miles a second and the most distant known object in the universe—the Australian radio-astronomers who found it say the distance record set by the quasi-stellar object will not stand long.

They base their prediction on the 100 or more similar objects pinpointed by their radio telescope, the 210 ft. dish operated by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) at Parkes, New South Wales.

Mr. Bolton, the telescope's director, says the chances are that a few of these objects still awaiting investigation by optical astronomers, are even further out in space than 0106+01. If so, and enough quasars are found, many

scientists believe that important new theories about the nature of the universe will emerge this year.

GHOSTS TAKE TO THE SKY

A series of GHOST (Global Horizontal Sounding Technique) weather balloons will waft across the Australian continent this year as part of an important scientific study to determine the circulation patterns of the upper air in the southern hemisphere.

GHOSTS, hydrogen-filled balloons 8 ft. in diameter, carry a high-frequency transmitter that can be heard 3000 miles away. As they drift across Australia, information radioed back from the balloons will be received at a ground station in Melbourne in the State of Victoria.

Similar monitoring stations set up in other southern hemisphere countries, including New Zealand, Chile, Argentina, South Africa and Mauritius, will listen to the signals sent from the balloons as they travel across these regions.

The GHOST project envisages the use of one or more satellites to read out data from large numbers of balloons at several levels between 20,000 and 80,000 ft. over the entire surface of the earth.

Before the project is launched, however, balloon capabilities and electronic measuring equipment must be tested from a number of ground stations. This test programme, under the direction of the National Centre for Atmospheric Research at Boulder, Colorado, is now under way in the southern hemisphere.

Normally, little meteorological information is obtained from the southern hemisphere because of its vast oceans and the upper wind currents associated with them. For this reason, the southern hemisphere has the most to gain from the balloon programme. Ultimately, the project will allow Australia and other countries to make accurate long-range weather forecasts.

The first test flight took place from Christchurch, New Zealand, recently with other flights being launched over a period of six months. As the balloons might remain at altitude for periods of six months or longer the test programme will continue for 12 months.

If the test programme is successful, plans are ready for the launching of 10,000 constant level free-floating balloons to obtain atmospheric measurements on a global basis.

Mr. W. J. Gibbs, Director of the Federal Bureau of Meteorology based in Melbourne, describes the GHOST project as 'one of the most exciting developments in meteorology for many years'.

While satellites provide pictures of the earth's cover and weather systems, the balloons will make available additional details that will help fill in the gaps in man's knowledge of the weather.

GHOST will provide valuable information for World Weather Watch, for which Melbourne has been nominated as the southern hemisphere centre. The

other centres are in Moscow and Washington.

World Weather Watch will come into operation in 1968 to provide a comprehensive system for collecting, processing and using weather information to make forecasting in every part of the world more reliable.

One of its main advantages will be improved forecasts of typhoons and tropical cyclones. Another will be that any possible relationships between patterns of drought in the sub-tropical belt in the southern hemisphere and flooding in the northern hemisphere can be closely studied.

When World Weather Watch is fully operational, probably in 1971, the Weather Watch Centres in Melbourne, Washington and Moscow will be fed with weather information from collecting points around the globe.

The three centres will be connected by their own telecommunications to allow rapid exchange of data. This data will be analyzed and then relayed to meteorological centres in every country.

Information will flow into the three analysis centres for weather stations, by ships at sea and weather satellites. It will be analyzed by computer and daily weather patterns covering the world will be issued.

World Weather Watch developed from a resolution passed by the United Nations General Assembly in December 1961, urging international co-operation in the peaceful use of outer space.

Mr. Gibbs is Australia's representative at the World Meteorological Organization.

By Courtesy: Australian High Commission, New Delhi.

Problems in Mathematics

J. N. Kapur and R. C. Sharma

We have started a new feature under the name 'Problems in Mathematics'. Readers may send their solutions to the Editor before August 15, 1967. The correct solutions will be printed along with the name of the person who had solved it correctly and elegantly in the next issue. The problems are all numbered as SS1, SS2 and so on. In sending the solutions please remember to quote these numbers. Readers may also send problems for this section along with their complete solutions.

The problems in this article have been framed or selected by Prof. J. N. Kapur

We hope this section will interest a large number of bright students of mathematics, who will attempt to solve these problems.

—Editor

CHALLENGING Problems and their ingenious solutions have always constituted the heart of the exciting intellectual enterprise that is known as mathematics. Young men and women all over the world have found it worthwhile to attack challenging mathematical problems and spend days, weeks and even months in solving individual problems. The question naturally arises as to why the young mind is willing to make this supreme effort. According to Prof. Gabor Szego, 'The explanation is probably the instinctive preference for certain values, that is the attitude which rates intellectual effort and spiritual achievements higher than material advantage. Such a valuation can be the result of only a long cultural development of environment and public spirit which is difficult to obtain by government aid or even by more intensive training in mathematics. The most effective means may consist of transmitting to the young mind the beauty of the intellectual work and the feeling of satisfaction following a great and successful mental effort.'

This section here aims to give a taste of creative intellectual adventure to the young Indian students with the hope that once they have tasted the fruits of intellectual efforts, they will never forswear it in their later life. They may or may not become mathematicians later on, and this is immaterial; but it is hoped that they will retain a taste for the type of intellectual effort represented in the solution of such problems. This section is meant for all students and teachers of mathematics and science in schools. We would however, value the active participation of all those who find mathematical problems intellectually exciting and who may like to take to proposing and solving mathematical problems as a hobby. Such persons may be physicists, chemists, biologists, economists and even lawyers, judges and businessmen. In fact non-professional mathematicians have always participated in intellectual mathematical activities and their participation has been responsible for the creation of the intellectual climate in which mathematics has prospered.

The problems proposed here will be entirely different from the drill problems occuring in textbooks. They will be elementary in the sense that no techniques beyond those taught at the secondary school level will be required for their solution. The problems

will however, require a great deal of thinking and ingenuity and an insight into the nature of the mathematical structures taught in schools. Some of them may be easy and may require a few minutes of clear thinking, while others may require hours of intensive intellectual effort.

We publish here the first set of problems:

SS1. Multiply 89 by 87 by using (i) the multiplication table of 2 only (ii) the multiplication tables of 2 and 3 only (iii) the multiplication tables of 2, 3 and 4 only. You may use scales to bases 2, 3, 4 respectively.

SS2. Show that :

$$\frac{1}{n-3}+\frac{1}{n-2}+\frac{1}{n-1}+\frac{1}{n}+\frac{1}{n+1}+\frac{1}{n+2}+\frac{1}{n+3},$$

where n is an integer greater than 3, cannot be expressed as a terminating decimal.

SS3. Find an arrangement of 36 numbers in 6 rows and 6 columns which is such that when we select, out of these 36 numbers, six numbers of which no two belong to the same row or same column *i.e.*, if we take only one number from each row and only one number for each column, the sum of the 6 selected numbers always comes out to be 1967. Generalize your result to give a general method for arranging n^2 numbers in n rows and n columns such that the sum of the n numbers, one from each row and one from each column, is a given number m.

SS4. Suppose in SS3 we take $n=20$ $m=1967$ and suppose it takes one second to choose 20 numbers, one in each row and one in each column and check that the sum is 1967, estimate how many years it would take to verify all the possible sums, for a given square array. How many years would be required if $m=30$?

SS5. Suppose in SS3, instead of the sum of the n selected numbers being m, we require their product to be a given number m. Is it possible to solve this problem for all values of n and m? Solve the problem for $n=3$, $m=5040$.

SS6. Use all digits 1 to 9 once and only once and the plus sign to get the sums 99, 1368, 19134, 100008.

SS7. In every possible answer to SS3, we can find the following two numbers (i) the minimum number in each row and then the greatest of these row minima (ii) the maximum number in each column and then the smallest of these column maxima. Prove that in every case the first number will be less than or equal to the second number.

SS8. Write all numbers from 1 to 50 in terms of four 4's and the symbols +, –, ×, ÷ and decimals.

(Selected)

SS9. If $[x]$ is the integral part of x *e.g.*, if $[6]=6$, $[7.4]=7$, $[0.5]=0$, $[-1.5]=-2$ and if n and k are positive integers and k is greater than 1, then prove that

(i) $\left[\frac{2n}{k}\right] \geqslant \left[\frac{n}{k}\right] + \left[\frac{n+1}{k}\right]$

(ii) for any number x,

$$[x]+\left[x+\frac{1}{n}\right]+\left[x+\frac{2}{n}\right]+\cdots+\left[x+\frac{n-1}{n}\right]=[nx]$$

(Selected)

SS10. Find the smallest integer whose value is trebled if the left hand digit is transferred to the right hand end. (Selected)

SS11. If $a_1, a_2, a_3, \ldots\ldots\ldots\ldots, a_n$ are positive numbers whose sum is A, then show that

$$a_1a_2+a_2a_3+a_3a_4 \ldots\ldots +a_{n-1}a_n \leqslant A^2/4$$

(Selected)

SS12. The following are n simultaneous equations in the unknowns $x_1, x_2, \ldots\ldots\ldots, x_n$

$$\begin{aligned}
x_1 + x_2 + x_3 + x_4 &= 0\\
x_2 + x_3 + x_4 + x_5 &= 0\\
x_3 + x_4 + x_5 + x_6 &= 0\\
x_4 + x_5 + x_6 + x_7 &= 0\\
\text{— — —} &\text{ — —}\\
\text{— — —} &\text{ — —}\\
x_{n-3}+x_{n-2}+x_{n-1}+x_n &= 0\\
x_{n-2}+x_{n-1}+x_n+x_1 &= 0\\
x_{n-1}+x_n+x_1+x_2 &= 0\\
x_n+x_1+x_2+x_3 &= 0
\end{aligned}$$

For what values of n do these equations have a unique solution? When the solution is not unique, write down the general solution.

SS13. All the even integers beginning with 2 are written successively (that is as 2 4 6 8 10 12 14 16 18 20——) which digit occupies the 100,000th position? Which digit will occupy the 100,000th position if all multiples of 3 are written in the same manner?

SS14.

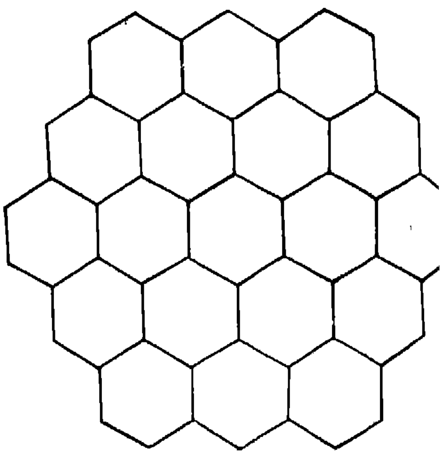
(i)	(ii)
NINE	SEVEN
−TEN	−NINE
TWO	EIGHT

Find what digits should replace the letters so that the above subtraction sums may be correct?

(Selected)

SS15. Fill in numbers in the hexagons (below) so that the sum of every row of 3 hexagons is 30, of every row of 4 hexagons is 40 and of every row of 5 hexagons is 50 The rows can be horizontal or inclined

(Adapted)



PROGRAMME OF SUMMER INSTITUTES

SUMMER SCIENCE INSTITUTES (1963-66)

During the period 1963-66, the University Grants Commission in collaboration with the National Council of Educational Research and Training and United States Agency for International Development organized at various universities, 112 summer institutes in science and mathematics for teachers from high/higher secondary schools /PUC/Intermediate colleges attended by 4,299 teachers in mathematics, physics, chemistry and biology. The number of institutes held during this period and the enrolment at the institutes are given below:

	No. of Participants				
Year	Mathematics	Physics	Chemistry	Biology	No. of Institutes
1963	34	43	38	39	4
1964	169	170	148	153	16
1965	616	488	464	261	49
1966	490	468	410	308	43
Total	1,309	1,169	1,060	761	112

The total number of American consultants associated with the academic programme of the institutes was 212.

Programme for 1967

In the summer of 1967, 61 summer institues will be organized : Biology 13, Chemistry 16; Mathematics 15; Physics 17.

LOCATION AND DURATION OF SUMMER INSTITUTES

Sl No.	University	Institute Dates	Regions Covered by the Institute	Director
1	2	3	4	5
			BIOLOGY	
EASTERN ZONE				
1.	Ranchi University, Ranchi	15 May-24 June	Bihar, West Bengal Assam, NEFA Nagaland, Manipur and Tripura	Prof. K.C. Bose, Head of the Deptt. of Zoology, Ranchi University.
2.	Regional College of Education, Bhubaneshwar	1 May-10 June	Training Colleges and Orissa	Dr. (Mrs.) G.R. Ghosh, Reader in Botany, Regional College of Education, Bhubaneshwar.
NORTHERN ZONE				
3.	Agra University (Agra College), Agra	15 May-24 June	Uttar Pradesh	Prof. C.P. Singh, Head of the Deptt. of Zoology, Agra College, Agra.

1	2	3	4	5
4	Delhi University, Delhi	5 June-10 July	Delhi and Haryana	Prof B.R. Seshachar, Head of the Deptt of Zoology, Delhi University
5.	Gorakhpur University, Gorakhpur	15 May-24 June	Uttar Pradesh	Prof H.S. Chowdhury, Head of the Deptt of Zoology, Gorakhpur University.
6.	Punjab University, Chandigarh	1 May-10 June	Punjab and Jammu and Kashmir	Prof P.N. Mehra, Head of the Deptt. of Botany, Punjab University.
WESTERN ZONE				
7	Gujarat University, Ahmedabad	20 May-30 June	Gujarat and Rajasthan	Dr M.S. Dubale, Reader and Head of the Deptt of Zoology, Gujarat University, School of Sciences, Ahmedabad.
8	Marathwada University, Aurangabad	15 May-24 June	Maharashtra	Prof. K.B. Deshpande, Head of the Deptt. of Botany, Marathwada University.
9	Poona University, Poona	22 May-1 July	Maharashtra and Madhya Pradesh	Prof. T.S Mahabale, Head of the Deptt of Botany, Poona University
10.	Regional College of Education, Ajmer	1 May-10 June	Training Colleges and Rajasthan	Dr. B.S. Shiva Rao, Regional College of Education, Ajmer.
SOUTHERN ZONE				
11.	Kerala University Centre, Calicut	24 April-3 June	Kerala and South Mysore	Dr. K.J. Joseph, Reader in Zoology, Kerala University Centre, St. Joseph College, Devagiri, Calicut.
12.	Madurai University, Madurai	24 April-3 June	Madras	Prof. S. Krishnaswamy, Department of Zoology, Madurai University
13.	Osmania University, Hyderabad	1 May-10 June	Andhra and North Mysore	Prof. M.R Suxena, Head of the Deptt. of Botany, Osmania University.

CHEMISTRY

1	2	3	4	5
EASTERN ZONE				
14	Jadavpur University, Calcutta	1 May-10 June	West Bengal and Orissa	Dr. A.K [illegible] in the [illegible], Jadavpur University.
15.	Patna University, Patna	1 June-15 July	Bihar, Assam, Nagaland, NEFA Manipur and Tripura	Prof. J.N. Chatterjee, Deptt. of Chemistry, Patna University.
NORTHERN ZONE				
16.	Banaras Hindu University, Varanasi	15 May-24 June	East Uttar Pradesh	Prof. G.B. Singh, Head of the Deptt. of Chemistry, Banaras Hindu University.

1	2	3	4	5
17	Lucknow University, Lucknow	29 May-7 July	West Uttar Pradesh, Delhi and Haryana	Dr I. N Srivastava, Deptt. of Chemistry, Lucknow University
18.	Punjab University, Chandigarh	1 May-10 June	Punjab, Jammu and Kashmir and Himachal Pradesh	Prof. R.C. Paul, Head of the Deptt. of Chemistry, Punjab University.
WESTERN ZONE				
19	Jodhpur University, Jodhpur	24 May-1 July	Rajasthan and Gujarat	Prof. R C. Kapoor, Head of the Deptt. of Chemistry, Jodhpur University
20.	Nagpur University, Nagpur	1 May-10 June	Maharashtra	Prof G V. Asolkar, Principal, Institute of Science, Nagpur
21.	Regional College of Education, Bhopal	1 May-10 June	Training colleges and Madhya Pradesh	Dr. K S Vishwanathan, Head of the Deptt. of Chemistry, Regional College of Education, Bhopal.
22.	Shivaji University, Kolhapur	22 May-1 July	Maharashtra and Goa	Prof. R.D. Shingte, Head of the Deptt. of Chemistry, Shivaji University
23	Vikrma University, Ujjain	15 May-24 June	Maharashtra and Goa	Prof. W.V. Bhagwat, Head of the Department of Chemistry, Vikram University.
SOUTHERN ZONE				
25.	Annamalai University, Annamalainagar	24 April-3 June	Madras	Dr. M. Balasubramanian, Reader in the Deptt. of Chemistry, *Annamalai University.*
26.	Bangalore University (Central College) Bangalore	1 May-10 June	Mysore	Dr. M. Shadaksharaswamy, Principal, Central College Bangalore
27.	Kerala University Centre, Ernakulam	24 April-3 June	Kerala	Prof. M.V Varghese, Head of the Deptt. of Chemistry, Sacred Heart College, Thevera, Ernakulam.
28.	Osmania University, Hyderabad	15 May-24 June	Hyderabad and neighbouring areas	Dr. V.R. Srinivasan, University College of Science, Osmania University.
29.	Regional College of Education, Mysore	1 May-10 June	Training Colleges and Mysore	Dr. S.R. Rao, Reader in Chemistry, Regional College of Education, Mysore.

MATHEMATICS

EASTERN ZONE				
30.	Bhagalpur University, Bhagalpur	1 June-14 July	Bihar	Prof. R.K. Choudhary, Head of the Department of Mathematics, Bhagalpur University.
31	Gauhati University, Gauhati	15 May-24 June	Assam, Tripura, NEFA, Nagaland and Manipur	Shri B.K. Tamuli, Deptt. of Mathematics, Gauhati University.

1	2	3	4	5
32	Jadavpur University, Calcutta	1 May-10 June	West Bengal	Dr. D.K. Sinha, Reader in the Deptt. of Mathematics, Jadavpur University.
33.	Patna University, Patna	15 May-24 June	Bihar and Orissa	Prof. R. Shukla, Head of the Deptt. of Mathematics, Patna University.
NORTHERN ZONE				
34.	Delhi University, Delhi	22 May-1 July	Delhi and Haryana	Shri P.D. Gupta, Principal, Ramjas College, Delhi.
35.	Jammu and Kashmir University, Srinagar	17 July-30 August	Jammu and Kashmir	Shri Jan Mohammad, Deptt. of Mathematics, Jammu and Kashmir University.
36	Kanpur University, (D.A.V. College), Kanpur	15 May-24 June	Uttar Pradesh	Prof. S.P. Nigam, Head of the Deptt. of Mathematics, D.A.V. College, Kanpur.
37.	Kurukshetra University, Kurukshetra	15 May-24 June	Punjab and Himachal Pradesh	Dr C. Mohan, Deptt. of Mathematics, Kurukshetra University.
WESTERN ZONE				
38.	Jabalpur University, Jabalpur	22 May-1 July	Maharashtra	Dr. T. Pati, Reader and Head of the Deptt. of Mathematics, Jabalpur University.
39.	Jiwaji University, Gwalior	22 May-1 July	Gujarat	Prof S. K. D. Gaur, Government Science College, Gwalior.
40.	Rajasthan University, Jaipur	15 May-24 June	Rajasthan	Dr. G.C. Patni, Head of the Deptt. of Mathematics, Rajasthan University.
41.	Regional College of Education, Bhopal	1 May-10 June	Training college and Madhya Pradesh	Principal P D. Sharma, Regional College of Education, Bhopal.
SOUTHERN ZONE				
42.	Bangalore University, Bangalore	1 May-10 June	Mysore and Madras	Prof. F.J Noronha, Head of the Deptt of Mathematics, Bangalore University.
43.	Kerala University, Trivandrum	1 May-10 June	Kerala	Dr. C.T. John, Deptt. of Mathematics, Mar Thoma College, Thiruvalla.
44	Osmania University, Hyderabad	1 May-10 June	Andhra	Prof. J. Ramkanth, Deptt. of Mathematics, Osmania University.

PHYSICS

EASTERN ZONE				
45.	Gauhati University, Gauhati	15 May-24 June	Assam and West Bengal	Prof. Harideb Goswami, Deptt of Physics, Cotton College, Gauhati
46	Patna University, Patna	6 May-15 June	Bihar and Orissa	Prof. M. N. Verma, Physics Deptt., Patna University.

1	2	3	4	5
47	Regional College of Education, Bhubaneshwar	1 May-10 June	Training Colleges and Orissa	Dr S.K. Kundu, Reader in Physics, Regional College of Education, Bhubaneshwar
NORTHERN ZONE				
48.	Agra University (Agra College), Agra	15 May-24 June	Delhi and Haryana	Prof. D.R. Khandelwal, Head of the Deptt. of Physics, Agra College, Agra.
49	Allahabad University, Allahabad	22 May-1 July	Uttar Pradesh	Shri Rajendra Singh, Reader in the Deptt. of Physics, Allahabad University.
50.	Banaras Hindu University Varanasi	15 May-24 June	Uttar Pradesh	Deptt. of Physics, Banaras Hindu University.
51.	Lucknow University, Lucknow	5 June-14 July	Punjab and Himachal Pradesh	Prof P.N. Sharma, Head of the Deptt. of Physics, Lucknow University.
52.	Punjab University, Chandigarh	1 May-10 June	Jammu and Kashmir	Prof. B.M. Anand, Head of the Deptt. of Physics, Punjab University.
WESTERN ZONE				
53.	Marathwada University, Aurangabad	1 May-10 June	Maharashtra	Prof. B.B. Laud, Head of the Deptt. of Physics, Marathwada University.
54.	Saugar University, Sagar	8 May-17 June	Madhya Pradesh	Dr. J.D. Ranade, Reader in the Deptt. of Physics, Saugar University.
55	Sardar Patel University, Vallabh Vidyanagar	1 May-10 June	Gujarat	Prof. A.R. Patel, Head of the Deptt. of Physics, Sardar Patel University.
56.	Udaipur University, Udaipur	15 May-24 June	Rajasthan	Prof. J. Verma, Deptt. of Physics, Udaipur University.
57	Regional College of Education, Ajmer	1 May-10 June	Training colleges and Rajasthan	Dr. D.C. Pandey, Head of the Deptt of Physics, Regional-College of Education, Ajmer.
SOUTHERN ZONE				
58.	Andhra University, Waltair	1 May-10 June	Andhra	Prof. T. Tiruvenganna Rao, Deptt. of Physics, Andhra University.
59.	Annamalai University, Annamalainagar	8 May-17 June	Madras	Prof. S. Sriraman, Head of the Deptt. of Physics, Annamalai University.
60.	Bangalore University (Central College), Bangalore	1 May-10 June	Mysore	Prof K.N. Kuchela, Deptt. of Physics, Central College, Bangalore.
61	Kerala University Centre, Alwaye	24 April-3 June	Kerala	Prof. K. Venkateswarlu, Head of the Deptt. of Physics, Union Christian College, Alwaye.

News and Notes

EXPERIMENTAL PROJECT FOR TEACHING OF SCIENCE AND MATHEMATICS UNDER UNESCO TECHNICAL ASSISTANCE PROGRAMME

With the decision that the materials developed under the Experimental Project will be introduced in class VI of 104 central schools with effect from July 1967, necessary steps have been taken to get the required number of textbooks and other instructional materials printed in time. Two new schools, the Delhi Public School and the Springdales School have also joined the project this year.

The following manuscripts have been sent to the Publication Unit for printing:

1. Arithmetic and Algebra for Class VI in Hindi.
2. Arithmetic and Algebra for Class VI in English.
3. Geometry for Class VI in Hindi.
4. Geometry for Class VI in English.
5. Physics for Class VI in Hindi.
6. Physics for Class VI in English.
7. Biology for Class VI in Hindi.
8. Biology for Class VI in English.
9. Curriculum Guide—Arithmetic and Algebra for Class VI.
10. Curriculum Guide for Geometry in Class VI.
11. Curriculum Guide for Physics in Class VI.
12. Curriculum Guide for Biology in Class VI.

The draft text materials of class VII chemistry have been printed in Hindi. English version of the same has also been prepared. Curriculum Guide and Teacher's Guide for class VII chemistry are also ready.

A draft programme of 15 days' summer refresher course has also been prepared.

Teacher's Handbook of General Science for Classes I to V

The manuscript for the third volume of the handbook comprising of the units on biology, human body, health hygiene, and safety and first aid has been completed and sent to the Publication Unit. It is hoped that the Teacher's Handbook of Science will be out within a couple of months.

Curriculum Project—Study Groups

The Directors of the Biology Study Groups met on 11 February 1967 to discuss the syllabus in biology developed by the different groups. They decided to expand the topics by writing related instructional materials.

A meeting of the Physics Study Group was held at Jaipur on 6 and 7 March, 1967.

Two meetings of the Chemistry Study Groups were held at Poona and Hyderabad on 23 to 25 February, 1967 and 28 to 31 March, 1967 respectively.

National Science Talent Search Scheme

The Science Talent Search Examination 1967 was held on 1 January, 1967 at about 330 centres spread throughout the country.

A meeting of the Directors of the Summer Schools, proposed to be organized for the awardees of the Science Talent Search Scheme at different places in India during the summer of 1967, was held at the Department of Science Education on 27 and 28 February, 1967

At this meeting the entire programme of the summer schools was reorganized. It was decided that the schools will be held classwise and subjectwise. Further, M.Sc. students will be attached to National Laboratories for higher type of research project work.

An informal meeting of the Science Talent Search awardees of Delhi territory was convened on 6 March, 1967 at Hans Raj College, New Delhi. At this meeting it was decided that an All India Organization of Science Students should be organized through the initiative of the Science Talent Search Scheme scholars and a quarterly journal on scientific themes should be brought out.

Books for your science library

METALS, ATOMS, ALLOYS. C. L. McCabe and C. L. Bauer, Vistas of Science 9. 50c.

This book on *Metals, Atoms and Alloys* describes how scientists and technologists apply knowledge of the behaviour of atoms to the ancient art of metallurgy. Metallurgy, as the authors present it, deals with the basic sciences of physics and chemistry and with certain aspects of engineering concerned with metals—from the reduction of the ore of the metal to the attainment of desired properties in the final product. The readers are taken to the world of crystals wherein lies the answer to the question, 'What is a metal?'

The book tries to relate the basic principles taught in high school science courses to some of the technical problems encountered by metallurgists. There is a last section of the book which deals with 'Projects and Experiments'. Each experiment illustrates at least one important metallurgical principle.

NUTRITION, SCIENCE AND YOU. Mickelsen, Olaf. Vistas of Science 10: Produced by National Science Teachers Association. Scholastic Book Services, Division of Scholastic Magazines, Inc., New York. 50c.

In an earlier issue (School Science 3 (3) 1964) the other books in this series Vistas of Science were reviewed. Three more titles have been published since then. *Nutrition, Science and You* is the tenth of the series. This booklet tells the story of man's great intellectual quest to understand the relationship of food to his well-being. A century ago, the nutrition scientists found that changes in diet could save men's lives. Today they strive to learn more about the chemistry of food and the necessity to feed all the earth's people. In its nine chapters on different topics, the facts about the historical development of man's knowledge about the effect of food are well interspersed with discussions of the research conducted to test hypotheses and to search continuously for greater knowledge.

In the first few chapters the major essential components like water, proteins, fats and carbohydrates are described and in the later chapters, the vitamins and minerals. There is a chapter on growth and development and another on the challenge of research. There are some good selected readings given for those who are interested in the subject. The book is very useful to learn not only about the chemistry of food but also about the food and its relationship to man's life. The important details given here will

usefully supplement the knowledge gained in a classroom.

LIFE BEYOND THE EARTH.

Samuel Mottat and Elie A. Schneour. Vistas of Science 11. 50c.

Whether life as we know it on earth exists on other planets has been an exciting speculation by the scientists as well as laymen. But with the planned probes by man, to the moon and even venus, the speculations are no longer fancies. The search for life is on in earnest. The authors explore the thrilling possibilities of life elsewhere in the universe in this book. It presents an analysis of key role played by the carbon atom in the chemical evolution of terrestrial life, an examination of current theories concerning the development of life in our and other solar systems, and a discussion of space probes, life detection devices, and man's attempts to hear signals sent by intelligent life on distant worlds. The book is interesting as well as informative.

S. DORAISWAMI

SENIOR SCIENCE FOR HIGH SCHOOL STUDENTS.

Part II Chemistry. Nuclear Research Foundation with the University of Sydney, Australia p. 443. 1953.

The tremendous increase in scientific knowledge coupled with the spectacular achievements of the USSR in the field of nuclear and space research have caused every country to set up and revise their pattern of science education suited to its own environmental socio-economic conditions. The National Science Foundation in the USA, the Nuffield Foundation Project in the UK, and the Nuclear Research Foundation at the University of Sydney in Australia have all taken up this important revision and modernization of the science curriculum.

It is still a debatable point whether science should be taught in school as an integrated whole 'general science' or as separate disciplines. We in India have opted for the latter scheme and it is expected that science will be taught as separate disciplines during the last six years of the high schools in India.

In Australia, however, the nuclear research foundation group have decided to teach the subjects of physics, chemistry, biology and geology in an integrated form, in one course, and thus the book 'Science for High School Students' has been produced (reviewed Vol. 3 No. 2, 1964 p. 209) by NRF of the University of Sydney. The book under review is an extension of the above mentioned book. It has been written for the last two years of school course during which period physics, chemistry and biology would be taught as separate disciplines.

As Prof. Messel puts it 'In Science for High School Students the disciplines are integrated in a strong fashion, in Senior Science for High School Students the integration is of a more tenuous nature —we say the disciplines are interlocked'.

The present review concerns only with Part II of Senior Science For High School Students, the section dealing with chemistry.

There are 21 chapters* in this book and the treatment is quite modern and novel. Contrary to the practice in many other textbooks wherein an enormous volume of disjointed facts and obsolete processes are arrayed, the topics chosen in this book are directed towards the inculcation of important scientific principles without, however, completely ignoring essential factual knowledge. The main body of the chapter is followed by a summary and then questions. These are followed by practical work and finally by a list for further reading. It is an excellent treatise which should find a place in every school library. It is also eminently useful for the more brilliant of our students who wish to continue the study of the subject. In short it is 'An excellent work'.

**Chapter headings*

1. The behaviour of gases. 2. Reaction between gases and the formulae of substances. 3. Chemical equations. 4. Energy in chemical reactions. 5. Energy and chemical bonding. 6. The elements. 7. Halogen compounds. 8. Oxides. 9. Chemical periodicity. 10. Atomic structure and its history. 11. Chemical bonds and shapes of molecules. 12. Ions and crystals. 13. Hydrogen compounds. 14. The hydrides of carbon and some related compounds. 15. Solutions and chemical equilibrium. 16. Acids and bases. 17. Electron transfer reactions. 18. Substitution and addition reactions. 19. Mechanism and rates of chemical reactions. 20. Transition metals and oxidation states. 21. Complex compounds.

C. RADHAKRISHNAN

NUFFIELD BIOLOGY

The Nuffield Foundation Science Teaching Project Biology. Teacher's Guide 1: *Introducing living things.* pp. xviii + 152. 15s. Text: pp: x + 179. 15s. 6d. Teacher's Guide 2: *Life and living processes.* pp. xviii + 125. 15s. Text: pp. 162. 13s. Teacher's Guide 3: *The maintenance of life.* pp. xviii + 248. 20s. Text: pp. vii+238. 17s. 6d. Teacher's Guide 4: *Living thing in action.* pp. xviii+205. 20s. Text: pp. 313. 21s. *Keys in small Organisms in soil litter and water troughs.* pp. 27. 2s. (London): Longmans, Green and Co., Ltd.; Harmondsworth, Middx.: Penguin Books Ltd., 1966. Published for the Nuffield Foundation.

THESE books consist of a series of student texts and teaching guides, intended to cover 5 years' work in biology from age 11 to 16, leading to "O" level at age 16. The examining boards for the General Certificate of Education (GCE) have agreed to set alternative examinations on this syllabus, and the first candidates, from schools which have been experimenting with the scheme, took the examination in 1965. The books have been prepared under the direction of the Nuffield Foundation by a group of teachers seconded for the

purpose, with advice from scientists in universities and research institutions, and with the help of teachers and pupils in 170 schools which have tried out the syllabus in whole or in part, and have reported on their experiences. In addition to the books, a number of 8 mm films have been prepared, and costed lists of the apparatus required are available. Although the syllabus has been planned as a coherent whole, the authors believe that the final 3 years could be used without the first two, and that particular experiments should be introduced into a more orthodox syllabus.

I find it difficult to restrain my enthusiasm for these volumes. They seem to me admirable both in what they attempt to do, and in the way in which they do it. Science is presented as an activity directed to the solving of problems and the satisfaction of curiosity. On page after page, experiments are described which will enable children to answer for themselves questions about how animals live. One of the great potential virtues of Biology as a school subject is that it abounds in problems which can be answered with little or no apparatus in a school classroom. It therefore lends itself to teaching the scientific method, which is, after all, intended for the solution of problems and not for demonstration of truths stated in textbooks. Another virtue of biology as a school subject is that its problems are not abstract ones of interest only to the philosophically minded, but have an obvious human relevance. This relevance is also admirably brought out.

But what differentiates these volumes from other textbooks is not their objectives but the care with which they have been prepared. Reading the pupils' texts and the teacher's guides, it is at once apparent how much has been gained by trying out the syllabus in a variety of schools before presenting it in its present form. All sorts of snags are pointed out, and the methods of avoiding them explained, with a degree of foresight which could not be achieved in any other way. The result is a series of suggestions for experimental work which are at the same time ambitious and practicable.

Is too much being asked, either of pupils or of teachers? This question is bound to be asked. The best answer is that these courses have already been followed successfully in many schools which have been collaborating with the Nuffield Foundation. If the syllabus seems modern in comparison to that followed in many university courses in biology, it is because they are still in many cases following a direction which was anachronistic when it was laid down a hundred years ago by T. H. Huxley.

It seems clear that the syllabus is one which children can follow, and that teachers, given adequate facilities, can teach. But will teachers be given adequate facilities? A course consisting of experiments on living organisms is inevitably more expensive, both in apparatus and time, than the examination of dead material. But if new methods of teaching will help to produce a generation of school children for whom science

is a means of satisfying curiosity, instead of the impersonal, incomprehensible and often distasteful business, it so often is today, the small additional cost will surely have been worth it.

J. MAYNARD SMITH

From NATURE, Vol. 212.

Synthetic High Molecular Substances : I

V. A. Glushenkov
and C. Radhakrishnan

HIGH molecular substances are those which have high (large) molecular weights. The molecular weights of these substances are expressed by tens, thousands, lakhs, and millions of oxygen units. These substances are also called polymers.

Molecules of high molecular substances are much bigger and occupy a larger space than molecules of substances with small molecular weights. That is why high molecular substances are called macro-molecules. But the structure of macro-molecules is simpler than some substances with low molecular weights, *e.g.*, dyes and drugs.

It can be shown that molecules of polymers are built up from simple units, by repetition of these units several times, *e.g.*, CH_2 CH_2 CH_2 CH_2- The number of units which make up the chain is called the degree of polymerization or coefficient of polymerization. The difference between high molecular substances and those having lower molecular weights is that all macro-molecules do not have the same length of chain, *i.e.*, they consist of different number of elemental units. So a polymer is a mixture of polymer-homologues with different degrees of polymerization. But in this case they have the same properties, because they have the same structure. The molecular weight of the polymer is the average of the polymer-homologues. *Polymer-homologues consist of one* substance but ordinary homologues are different substances.

Structure of Molecules, Important Properties and Classification of Synthetic High Molecular Substances

The properties of synthetic high molecular substances depend on the size of their macro-molecules, on their molecular weights and on the structure of the elemental units. Most of the synthetic high molecular substances are organic compounds. Among them there are carbon-chain polymers which consists of elemental units of carbon, and hetero-chain polymers, which consist of elemental units with not only carbon, but other atoms as well for example O, N, S. Recently very important substances called silicon organic polymers with elemental units consisting of C, Si and O, have been evolved.

Besides the structure of chain, the properties of polymers are greatly

influenced by functional groups, which consist of Cl, FCN, OH etc., in their elemental units, *e.g.*, $(-CH_2-\underset{\underset{Cl}{|}}{CH}-)_n$,

$$(CH_2-\underset{\underset{CN}{|}}{CH}-)_n.$$

Most of the high molecular substances are non-volatile.

The behaviour of high molecular substances differs on heating. Some of them soften and become liquefied. Others decompose on heating, without liquefying. High molecular substances dissolve with difficulty and even those which dissolve, do so slowly and their solutions are viscous. Many do not dissolve at all. The high molecular substances are characterized by high mechanical strength. These properties are explained by the large force of their inter-molecular interaction. This force is more than the original force of chemical bond in the molecule. For example, for breaking a chemical bond between two carbon atoms (C–C) in a molecule like $-CH_2-CH_2-CH_2-CH_2-$, it is necessary to have 80 K. cals per gram mol, but for separating two CH_2 groups of different molecules only $\frac{1}{2}$ K cal is needed. But in the case of two parallel molecules consisting of 100 CH_2 groups each, it is necessary to spend much more than 80 K. cals. Thus it is clear, why it is difficult to separate macro-molecules during melting or dissolving During heating, sometimes breaking of C–C– bonds is easier than separating macro-molecules. Such strong inter-molecular interaction is the cause of the high mechanical strength of the polymers. The structure of elemental units also influence the strength of polymers. When elemental units have polar groups, attraction between molecules is greater and the strength increases. For example, in molecules of polychlorovinyl, electron pairs connecting atoms of carbon and chlorine in elemental units are moved from C to Cl $(-\underset{\underset{Cl}{|}}{CH}-)$ with the result that the atom of chlorine gets a part of the negative charge and the group $-\underset{|}{CH}-$ gets part of the positive charge.

$$\left(-\overset{\delta+}{\underset{\underset{Cl\delta-}{|}}{CH}}-\right)$$

It is natural that with the presence of such charged units in another molecule of polymer, interaction between such units will be more strong than uncharged units.

The special mechanical strength of polyamide fibres explains that besides inter-molecular interaction, there are also hydrogen bonds between positively charged atoms of hydrogen and negatively charged atoms of oxygen in amide groups of different molecules. Such interaction may be demonstrated by taking the example of nylon.

This has a great significance in the form of geometrical structures of molecules.

There are three basic structures of polymers: (i) linear (ii) branched and (iii) three dimensional.

Linear: Macro-molecules have linear structure if elemental units (A) produce a long chain of atoms. Such molecules are also called "chain-molecules". They have a very long macro-molecule, and look like a thread. We can describe a linear structure graphically as ... -A-A-A-A-A-A-... where A

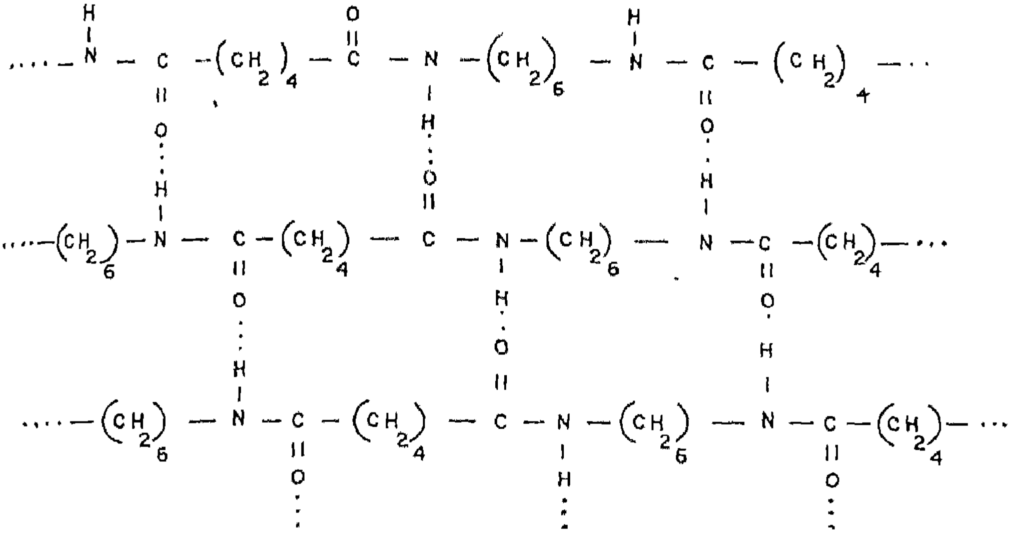


Fig. 1

is an elemental unit. Among the natural polymers of linear structure are cellulose and natural rubber and among the synthetic polymers are polyethylene, polychlorovinyl, nylon etc.

Branched: If the chains have branches which are produced during the production of polymers such a structure is called a branched structure.

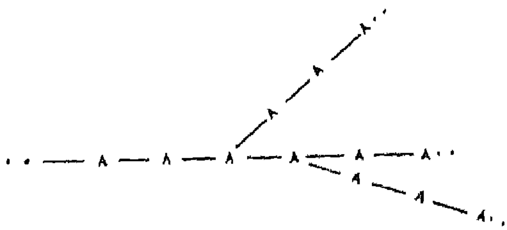


Fig. 2

Among the natural polymers having a branched structure is starch and among the synthetic polymers are the ones known as 'grafting polymers'. These are discussed later.

Three Dimensional: To produce the three dimensional structure, chains of polymers are joined in several parts, to one another with the help of chemical bonds. Even though it is difficult to represent a three dimensional structure (in one plane) it may be schematically shown as in Fig. 3.

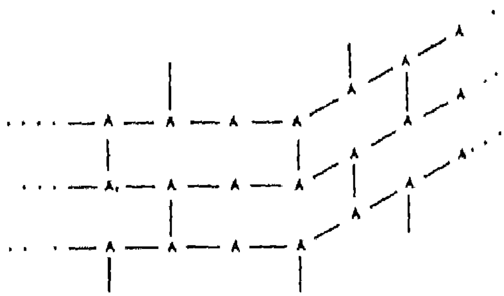


Fig. 3.

Such structures are sometimes called extra-molecular structures. Here the notion of the molecules is different from the usual one because all the linear or chain molecules of the sample knit into one gigantic molecule As examples of three dimensional structures can be cited phenol formaldehyde and urea formaldehyde resins, and also vulcanized rubber in which molecules are knitted

together with the help of sulphur into a three dimensional structure.

The properties of the polymers mentioned above depend on their structures. For example, substances with linear structure are elastic and on heating soften and sometimes melt. They also dissolve. Substances with three dimensional structure do not dissolve or melt but they decompose on heating. These differences in the properties of linear and three dimensional structures may be explained on the basis of the fact that the linear molecules in a three dimensional structure not only attract one another with the help of inter-molecular interaction but also have the real chemical bonds.

Notions about amorphous and crystalline state are very important in the study of polymers. The huge molecules settle down in such a way that in one place they could be parallel to one another, while at another place they settle down at random without any particular order. The first case gives rise to a crystalline structure and the other gives rise to an amorphous structure.

The more crystalline parts in a polymer the better is the strength. Such polymers soften after a long time on heating and do not melt, but they decompose instead.

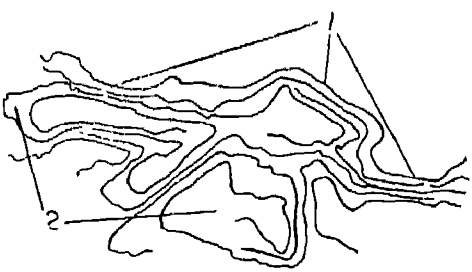


Fig. 4

Distribution of (1) crystalline and (2) amorphous areas in molecules of polymer, e.g., rubber

In recent years scientists have been able to produce polymers with regular positions of substituents in space. Such polymers are called 'stereo-regular'. Let us illustrate this by taking an example.

$$\left(CH_2\ \underset{\underset{R}{|}}{CH} \right)_n$$

Let the molecules of the polymer be in one plane. The alkyl groups can distribute in different ways with respect to the plane of the molecular chain. The polymers are called 'isotactic' (same order) (Fig. 5A) or 'syndiotactic'

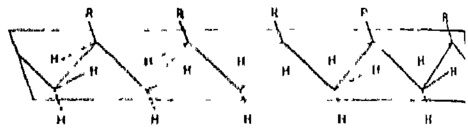


Fig 5A

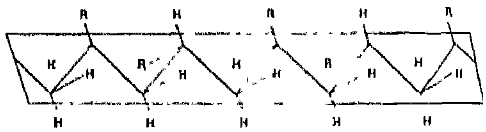


Fig 5B

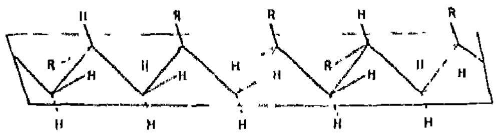


Fig 5C

(alternate order) (Fig. 5B), depending upon whether all the R groups are situated on one side of the plane or are distributed alternatively (one above the plane and the other below). There is a third type of polymers in which the arrangements of R groups are irregular and these are called atactic (Fig. 5C)

The first two structures A and B are stereo-regular. The third structure C

is irregular. Stereo-regular polymers have a high degree of crystalline nature (nearly 100 per cent) because their molecules are closely packed together. Crystalline stereo-regular polymers have also high melting temperatures (the internal temperature during which the crystalline substance becomes amorphous—melting range) and they have also a higher mechanical strength than irregular polymers. For example, the temperature of softening of the stereo-regular polystyrene is about 200°C but ordinary (irregular) polystyrene softens even in hot water. Natural rubber is an example of stereo-regular structure in natural polymers. It was very difficult to synthesize isoprene rubber because it was very difficult to synthesize a stereo-regular structure of macro-molecules. Recently this problem was solved in the USSR by A. A. Korotkov. In the field of synthesis of stereo-regular polymers, a lot of investigation is going on these days, and such synthetic materials will be increasingly produced industrially.

Methods of Preparation of Synthetic High Molecular Substances

Reaction of polymerization was discovered by A. M. Butleyrov in 1877, but it was only recently that any industrial use was found for it. In the reaction of polymerization, the molecules of monomers combine with one another without the elimination of any by-products. Such a procedure is characteristic of unsaturated substances. Molecules of each monomer combine, preceded by the breaking of double bonds. Usually unsaturated hydrocarbons and their derivatives take part in the polymerization reactions. For example, the following substances can take part in the reactions of polymerization;

$$\underset{\text{Ethylene,}}{CH_2=CH_2}\,,\quad \underset{\text{Vinyl Chloride.}}{\begin{array}{c}CH_2=CH\\ |\\ Cl\end{array}}\,,$$

$$\underset{\text{Vinylidene Chloride,}}{CH_2=CCl_2}\,,\quad \underset{\text{Tetrafluoro Ethene.}}{CF_2=CF_2}$$

$$\underset{\text{Propylene.}}{\begin{array}{c}CH_2=CH\\ |\\ CH_3\end{array}}\,,\quad \underset{\text{Vinyl Acetate.}}{\begin{array}{c}CH_2=CH\\ |\\ COO\,CH_3\end{array}}\,,$$

$$\begin{array}{c}CH_2=C(CH_3)\\ |\\ COO\,CH_3\end{array}\qquad \text{etc.}$$

Methyl Vinyl Acetate
(Methyl Methacrylate)

It can be noticed that the common formula for most of these compounds is $\begin{array}{l}CH_2=CH\\ \quad\;\; |\\ \quad\;\; R\end{array}$, and hence we can represent the reaction of polymerization, schematically as:

$$\ldots+\begin{array}{c}CH_2=CH\\ \quad\;\; |\\ \quad\;\; R\end{array}+\begin{array}{c}CH_2=CH\\ \quad\;\; |\\ \quad\;\; R\end{array}+\ldots\rightarrow\ldots-\begin{array}{c}CH_2-CH\\ \quad\;\; |\\ \quad\;\; R\end{array}-\begin{array}{c}CH_2-CH\\ \quad\;\; |\\ \quad\;\; R\end{array}-\ldots$$

or in an abbreviated manner as

$$n\begin{array}{c}(CH_2=CH)\\ \quad |\\ \quad R\end{array}\rightarrow -\begin{array}{c}(-CH_2-CH-)_n\\ \quad |\\ \quad R\end{array}-$$

The scheme does not show us the mechanism of the reaction of polymerization, but shows us only the order of bonds between atoms. It is the conventional representation of the reaction of polymerization with the help of structural formula.

Reactions of polymerization can take place in two ways:

1 By a step by step process (step polymerization).

2 as a chain reaction (chain polymerization).
Let us consider these one after the other.

Step Polymerization

This takes place with the increasing of molecular weight in steps. Combination of each monomer with another takes place with the formation of intermediate compounds which could be isolated. Products obtained during the cracking of petroleum, *e.g.*, propylene, isobutylene, etc., are used for step polymerization in industrial processes As a result we get high molecular substances which are used as engine fuels. Step polymerization takes place at low temperatures and at pressures which are not very high, in the presence of catalysts. The step polymerization of alkenes (conducted in the case of isobutylene in presence of H_2SO_4) was discovered by A. M. Butleyrov in 1873. As a result of that reaction, two isomers of di-isobutylene (a dimer of isobutylene) differing from each other by the position of their double bond were obtained.

Besides dimers, trimers, tetramers, etc., are also produced. The catalytic action of acids is through the production of esters, which practically ionise to give the positive organic ion of the monomer called the carbo-cation.

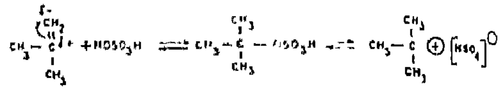


Fig 7

The intermediate ion with incomplete shell in carbon can attract new molecules of alkene in which there has been a movement of the electrons of the double bond, as a result of which that carbon atom with the least number of hydrogen atoms gets a positive charge. The carbo-cation of dimer is obtained as a result of interaction between the carbo-cation of the monomer and the extreme structure of another monomer. The carbo-cation of the dimer stabilizes by losing a proton, according to the Zeitzev's rule, which states that from among the neighbouring carbon atoms a proton is lost from that carbon atom which has the least number of hydrogen atoms. As a result of this, a double bond is created between the third and fourth carbon atoms and to a small extent between the fourth and fifth carbon atoms. The carbo-cation dimer that has lost a proton can act as a catalyst for the next step, for producing a new carbo-cation, or can be attached to the anions of the primary acid. In that case the catalyst is regenerated.

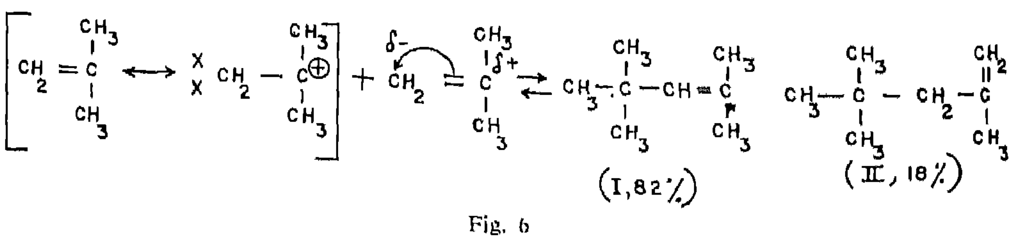


Fig. 6

After hydrogenation of this mixture

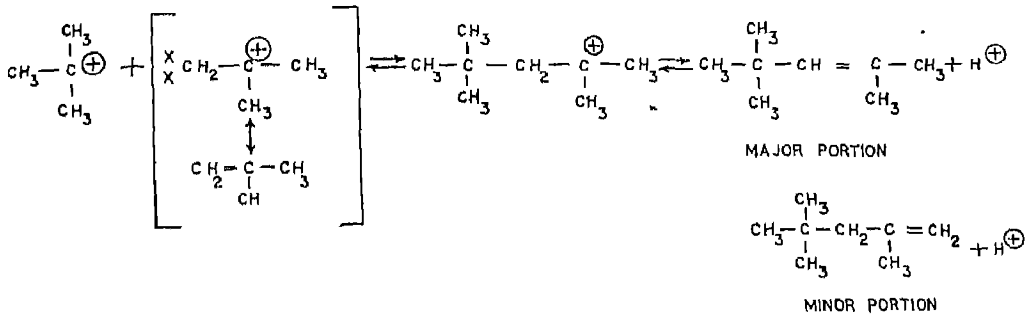


Fig. 8 Zeitzev's Rule

we get the saturated hydrocarbon Iso-octane with octane number of 100 (best fuel for motor cars).

Chain Polymerization

The mechanism of reaction of chain polymerization is analogus to the mechanism of reactions having the common name of chain reactions, the theory of which was discovered by the Soviet scientist N. M. Semyonov. There are three steps in the reactions of chain polymerization: (i) step of initiation of the reaction of polymerization; (ii) step of growing of chain and (iii) the breaking and stopping of the growth of chain. According to the type of intermediate active particles, at the beginning of the growing of chain, the following mechanisms of the reaction of polymerization can be given, (i) radical mechanism of polymerization which goes through the production of free radicals and (ii) ionic mechanism of polymerization, which takes place through the production of ions. The charge of ions can be positive or negative according to whether the mechanism of reaction of polymerization is cationic or anionic.

Radical Polymerization

Radical polymerization is one of the more important and well studied methods of synthesis of high molecular substances from low molecular substances. It may be represented schematically as:

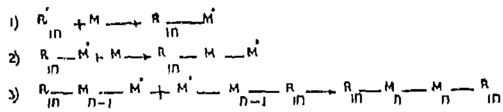


Fig. 9

1. Initiation: Obtains free radical of Macro-molecule
2. Growing of Chain
3. Breaking of Chain and stopping of Growth

Initiation of Radical Polymerization

In this step the active free radical is produced from the molecule of the monomer, and as a result there will be an unpaired electron in the free radical. Such production of free radicals can be accomplished by the action of temperature (thermal polymerization), light (photochemical polymerization) or rays of particles of high energy (radiation polymerization). Initiation of polymerization has been studied in detail and is very important. Peroxides, hydro-peroxides and some azo and diazo compounds are used as initiations

of this reaction. They are capable of decomposition with the production of

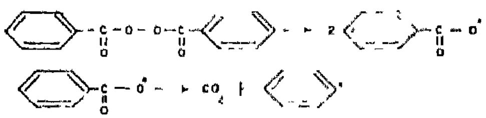


Fig. 10

free radicals. Benzoyl peroxide is used in such cases very often. The decomposition of benzoyl peroxide takes place in a complicated manner and as a result we get two kind of free

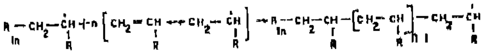


Fig. 11

radicals: benzoate radical and phenyl radical.

The free radical obtained interacts with the unsaturated monomer and as a result of this interaction the double bond is broken and a new free macro-radical is obtained.

Growing of Chain

The main idea of the growing of macro-radicals is addition of the molecule of monomer to the macro-radical.

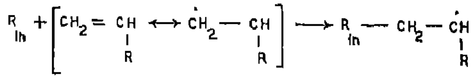


Fig. 12

Independent of the character of initiation the growing of macro-molecular chain starts from the moment of addition of the molecule of monomer to the first radical, and goes on up to the time when the growing chain attains radical structure.

As a result of kinetic measurements it is established that the reaction of growing of chain has an energy of activation which is extremely small (3-7 Kilocalories per mole). This energy is equivalent to the energy of activation in the free radical reactions. This may explain the very high speed of the reaction of growing of chain. The speed of reaction of growing of macro-radicals is independent of the length of the macro-radicals. The active centre on the end of the growing macro-radical is influenced by atoms of the radical chain which lie nearest to the active centre. This atom is always identical irrespective of the length of macro-radicals. But the speed of growing of the chain is influenced by the structure and properties of the monomer, and its substituents (steric influence, conjugation of bonds, polarization of monomer etc.).

Breaking and Stopping Growing of Chain

The process of growing of a chain will stop if a macro-radical meets another one or the first radical which is produced from the peroxide.

$$2R_{in} \quad CH_2 \quad \underset{R}{\underset{|}{CH}} \rightarrow$$

$$R_{in}-CH_2-\underset{R}{\underset{|}{CH}}-\underset{R}{\underset{|}{CH}}-CH_2-R_{in}$$

In that case the radical will combine and the final molecule cannot grow after that. There will then be a macro-molecule, having units of initiators at both ends. That is, initiator is spent on the preparation of macro-molecules of polymer. We can represent this process as:

Telomerization

With the help of special solvents

and other conditions for the process of reaction of polymerization (temperature, pressure and concentration of monomer) it is possible to so regulate the speed of the polymerization reaction as to get low molecular (weight) polymers. In macro-molecules of these,

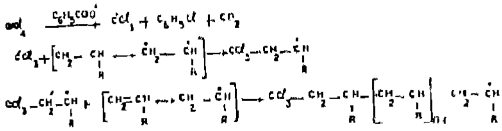


Fig. 13

there are units of the products of decomposition of the solvent (*e.g.*, CCI C_6H_5- CH_3) due to the presence of

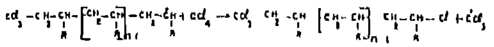


Fig. 14

very easily decomposable solvent (by influence of light or peroxide). This solvent can not only initiate the first radical but also cause the stopping of the growing of macro-radicals.

The growing of reaction chain is stopped when growing macro-radical meets another molecule of the solvent. Such a method of synthesis of new high molecular substances is very important today and is called the 'break polymerization method' or 'telomerization'. The molecule which breaks the chain is called 'telogen'. By telomerization of ethylene in the presence of CCI as a telogen the following telomers have been obtained.

$$_nCH_2{=}CH_2 + CCl_4 \rightarrow$$
$$CCl_3\text{--}(\text{-}CH_2\text{-}CH_2\ )_n\text{--}Cl \text{ where}$$
$$(n{=}2,3,4, \ldots \ldots 15)$$

Copolymerization

A very important branch of the reaction of polymerization is the reaction of copolymerization where the polymer is prepared from two or several different monomers. If we call the units of such a polymer as A and B the structure of copolymers can be represented as: $nA+mB\text{-} \rightarrow \ldots A\text{-}B\text{-}A\text{-}B\text{-}A\text{-}B$ ——... As a rule, there is no regular interchange of the units of both monomers. Such a copolymer has now properties which differ from the properties of the monomers and also their mixture. As an example can be cited a kind of synthetic rubber known as butadiene—styrene rubber which is a copolymer of butadiene and styrene.

From among the new methods of synthesis of polymers we can select two examples: (i) block copolymerization and (ii) grafting copolymerization.

Block Copolymerization

In the case of block copolymerization the macro-molecule of the new polymer is built by the regular interchange of blocks of different polymers. In practice such a copolymer can be obtained by methods of mechanochemistry, for example, by grinding together a mixture of two polymer fragments (blocks) which combine in the new copolymer molecule. The structure of block copolymers may be represented as follows:

$$\ldots.\text{—}(A)_n\text{—}(B)_m\text{—}(A)_n\text{—}(B)_m\text{—} .$$

Grafting Copolymerization

The main principle of such polymerization is that the macro-molecule of one polymer is grafted as a side branch on the macro-molecule of another polymer. In practice such a polymer is obtained if the polymerization of monomer (A) takes place in the presence of a molecule of another polymer (B)n. In that case molecules

of the monomer polymerizes on the macro-molecules as a side branch.

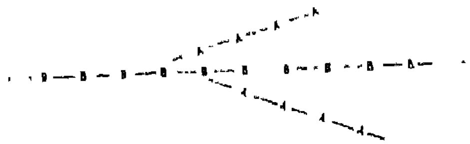


Fig. 15

With the help of such a method it is possible to obtain a polymer with very important properties and these properties are a combination of the properties of the component polymers. For example, block copolymer of natural rubber with chloroprene rubber combine the properties of natural rubber with the petrol and oil resistant properties of synthetic rubber

Ionic Polymerization

Ionic or catalytic polymerization takes place in the presence of different catalysts. With the help of ionic polymerization it is possible to regulate the reaction of the growing of macro-molecules and obtain polymers with predetermined properties. The unbranched polyethylene, isotactic polypropylene, isobutylene-styrene and others were synthesized by the method of ionic polymerization. These polymers have regular structures which improve their mechanical properties. As in the case of radical polymerization ionic polymerization is also chain polymerization. This process goes on through the obtaining of ions consisting of three-valency carbon having a positive or negative charge. There will be cation or onion polymerization depending on the sign of the charge on the three-valency carbon.

Polycondensation

High molecular substances could be obtained not only with substances having double bonds but also in those cases when the monomers have not less than two functional groups. The reaction of polycondensation takes place with the elimination of low molecular substances such as water, hydrogen chloride, etc.

The repeating structural unit in such a polymer is $-NH(CH_2)_6-CO-$, the composition of which is not the same as the composition of monomers. By means of the reaction of polycondensation it is possible to obtain polymers with several structures—linear, net, and three-dimensional. Such polymers as nylon, phenol, formaldehyde resins, etc., are obtained with the help of the reaction of polycondensation.

$$NH_2-(CH_2)_6-CO\boxed{OH+H}NH-(CH_2)_6-COOH \rightleftarrows H_2O+H_2N-(CH_2)_6-CONH-(CH_2)_6-COOH$$

$$H_2N-(CH_2)_6-CONH-(CH_2)_6-CO\boxed{OH+H}NH-(CH_2)_6-COOH \rightarrow H_2O+H_2N-(CH_2)_6-\underbrace{CONH-(CH_2)_6}-CONH-(CH_2)_6-COOH$$

Fig. 16

SPACE

Jacques Burko

Of the many decisive breakthroughs science has made since the beginning of the twentieth century, space exploration is the most complex and spectacular. The most far-flung branches of knowledge have come together in a central trunk which has led to feats unprecedented in the history of scientific conquest. For the first time, science has at its command research tools operable on a planetary scale.

Briefly, space has so far been explored by two methods: from the earth's surface, or with the help of vehicles, that we have just learnt how to launch into space.

The first of these methods—and the only possible one for the past thousands of years—obviously implies an indirect approach. Observation through telescopes, assisted by various accessories such as spectrographs, cameras, photometers and polarimeters, is its basic tool. The apparatus is sensitive to rays which are invisible to the naked eye, but rich in information concerning the bodies from which they emanate. Detectors of radio waves, X-rays, gamma rays and soon, of neutrino particles, are adding new weapons to our arsenal.

Other results are obtained by studying the meteorities reaching the earth's surface, and cosmic rays that manage to pierce our atmosphere. Then there are other branches of science that make major achievements possible in this field, even though their main purpose is not the exploration of the universe. Nuclear physics has enabled us to understand the process of thermonuclear fusion in the stars, the source of the tremendous energy which they send into space.

Ground-based methods of space investigation are thus developing rapidly, but it is the appearance of artificial satellites that will radically change our knowledge of worlds other than our own. The cosmic era, which began barely six years ago, is now teaching us more about our universe every day than we had learnt during years of observation from the earth.

First of all, satellites are irreplaceable for the study of our own planet. They give us an overall view of the earth which could never be

Reprinted from SCIENCE TODAY *Realities* 153 September 1963

obtained from its surface. Meteorological satellites, like Tiros and Nimbus, promise to make long-range weather forecasts possible. Geodetic satellites, such as Anna, accurately measure distances between the remotest points of the globe. Others, like Explorer or Cosmos, study space in our immediate vicinity Thanks to their findings, we now have a precise picture of the upper atmosphere and its various zones. We have discovered and explored the radiation belts girdling the earth—one of the most striking discoveries made by satellites—and we now know much more about the earth's magnetic field and the streams of micrometeorites that the earth encounters.

The study of other planets, too has been completely transformed by the appearance of space vehicles. It is fast becoming feasible to study the earth's neighbours—bodies within the range of our rockets, such as the Moon, Mars, Venus, and perhaps other planets in this system—directly, even on the spot. Observations with unmanned craft have shown the value of this method in the recent past ... and human crews will be used in the near future.

A few years ago, only a wild dreamer would have thought of strewing other planets with devices destined for transmission of pictures, soil analysis, measurement of magnetic fields and temperatures, and seismic recordings. Today, we are already calculating the orbits of future landings, and designing vehicles capable of climbing the rims of the Moon's craters.

Technological progress is accelerating in all fields—materials, fuels, electronics, remote control—as a result of the demands of space exploration, and it has made a race to the stars a feasible proposition But simultaneously other branches of technology, occasionally remote from space, benefit from the progress this race has stimulated.

As soon as we leave the narrow circle of planets within our immediate range, we have to give up all hope of further visits for the time being. It is possible that scientists will look into this problem in future, but the necessary means will certainly have to be much more powerful than the ones they now have. Our efforts today are limited to the direct study of immediate neighbours And even here science must continually surpass itself if it is to succeed.

But space vehicles are still of immense service in the exploration of bodies too distant for instruments to be landed on the spot, and indirect methods of study are now enjoying new opportunities. Satellites take the means of observation out of and beyond the earth's atmosphere, which in itself constitutes a great hindrance to observers.

One must not forget that the thick layer of air surrounding us is not nearly as transparent as we think. Astronomers must work as if through a layer of water some thirty feet deep. In fact, air is impervious to most of the electromagnetic waves sent to us by celestial bodies. This *roof* protects us from certain harmful rays, but it is also the despair of specialists, who have found only two peepholes in it.

The first peephole is visible light—we see the stars because the atmosphere lets pass the very rays which have the power of making an impression

upon our retinas. The second which has been known for only about thirty years, allows radio waves—of the same nature as visible light but lower in frequency—to pass. Radio telescopes are being more and more widely used, probing the sky to find and classify radio stars—the points in the sky from which these waves seem to come. We now know that many of these points correspond to visible celestial objects. Radio astronomers supply information to astronomers with optical telescopes for studies of galaxies, exploding stars, gas streams, and clouds of interstellar matter . . . Despite the help of radio astronomy, the ocean of air above us greatly limits our chances of learning the secrets of the universe. But by sending observation instruments beyond this layer, astronomers can obtain results that were once believed inaccessible. It is still impossible to load the huge Mount Palomar telescope abroad a spaceship, but much smaller devices can provide images far beyond the range of the most powerful instruments used on earth

These balloons, however, cannot remain at this altitude for very long, and it is expected that orbiting satellites will soon replace them and carry astronomical observatories on long journeys above the atmosphere. By travelling over the earth, these observatories will have an untold advantage over stations on the ground or in stratospheric balloons—they will be able to explore all regions of the sky without being limited to any fixed point on earth In addition to visible light, these space observatories will be able to work in the ultra-violet and infra-red ranges that frame visible light at either end of the spectrum, but are much more strongly absorbed by the atmosphere. In a later, but by no means remote stage, the Moon could be used for large-sized astronomical observatories, favoured by the fact that our natural satellite has no atmosphere

In addition to direct and indirect observation of celestial bodies, artificial satellites and space vehicles also study conditions in the interplanetary space through which they move Only six years ago scientists knew little about radiation in space, the matter scattered over it in the form of isolated particles, or micrometeorites, magnetic fields, and the streams of corpuscles that are thrown off by the Sun.

Physics is relying on these trips to learn the nature and origin of cosmic rays, their distribution in space and the reason for their moments of extreme energy. Present-day theories on the evolution of the universe are awaiting the arbitration of this science of 'experimental astronomy'

Here we are bringing in objectives that are more distant, and carry many more implications For example, one of the great problems concerning many different branches of science is the origin of life on earth and in the universe. Contradictory theories are waiting to be proved or disproved by facts, and it is in space that the facts are being found.

Radio Signals from Outer Space

The progress of astronautics is enabling us to learn whether life can exist on nearby planets and, if so, to what

extent it resembles ours. Elsewhere, progress in astrochemistry and astrophysics is informing us about conditions reigning on the surface of inaccessible worlds, and is even allowing us to reproduce these conditions in laboratories.

In one experiment Jupiter's surface environment has been reconstructed. Temperatures are very low and the chemical environment is radically hostile to our form of life: liquid ammonia, solid carbon dioxide, nitrogen, poisonous gases and methane, a strong magnetic field, powerful electric discharges, and intense cosmic radiation.

Under these conditions, experimenters have observed the gradual appearance of large, complicated molecules, components that could serve as the building bricks of living matter. Leading scientists, like the American Nobel Prize-winner Harold Urey, or certain Soviet specialists, maintain that the 'synthesis' of a form of life similar to ours is possible even under these conditions. Others, like Firsoff in Britain, envisage metabolisms very different from ours, in which liquid ammonia would replace water, and nitrogen oxygen.

These are all hypotheses which cannot be proved easily or quickly, but the seriousness of the search for organized and even intelligent life elsewhere was underlined by the Ozma experiment carried out a few years ago in America. It consisted of hunting systematically in space for modulated radio signals of the kind that might have been made by thinking creatures endeavouring to contact other minds. Nothing resulted from the project, but the search for life is still being intensively carried on.

One bitter quarrel today revolves around what certain scientists consider to be direct proof of the existence of life elsewhere. This proof is said to lie in carbon-bearing meteorites, the most famous of which fell at Orgueil, in France, a century ago. In these stones from heaven—possibly the remains of an exploded planet—research workers have found traces of matter of an organic nature, similar to that synthesized by living beings. Under the microscope, they have also seen structures resembling the vestiges of living cells. Here, they believe, is direct proof of the existence of life on other planets, and of the possibility of this life being transmitted from one planet to another by 'inhabited' meteorites.

The question is still a hot point of controversy—other scientists consider these proofs inadequate. In effect, it is possible that the meteorite fragments under study were contaminated by living organisms on earth after their arrival. It does seem hard to believe that fragile living matter could have survived the severe conditions of interplanetary space as well as the heat of entry into the earth's atmosphere. The only real way of setting this argument would be to 'capture' these meteorites outside the atmosphere, but such a project would have little chance of success.

Biology is facing other problems in space that concern us more directly. Man's ventures into space raise the problem of the effects of cosmic flight on living organisms. A first step has been taken, and the safety of short, low-altitude orbital flights has been proved.

But the problem of long flights far from earth still remains. We must study physical and psychological conditions facing crews during a trip from the earth to Mars, a trip which could last for months. Some day we may have to undertake journeys to other solar systems that will last for generations. At the moment, this still has a futuristic ring, studies are already beginning on the development of living embryos under space-flight conditions. For, it has been recognized that gravity plays a definite part in the development of the fertilized egg and, in particular, determines the orientation of the being's symmetry. The question now is: how would an embryo evolve in a state of non-gravity?

Nor can we ignore the enigma posed by relativity: at extreme speeds, time would pass more slowly for the astronaut than for his fellow-men on earth. When he returns he should find that he is younger than his contemporaries.

Even beyond the problems of life in the universe, there are now many hypotheses about the origin and evolution of the universe itself. Does it have an origin? Is it finite or infinite? Is it really dilating after an initial explosion, as certain thinkers believe, or is it in process of constant renewal? Till now, cosmogony was a matter more for hypotheses than precise experiments. But, with the new tools at science's disposal, it can reasonably be hoped that a decisive test of a coherent theory will one day be made.

SOYA BEAN

A Protein-rich Food

R. K. DATTA

SOYA bean (*Glycine max* (L.) Merrill), also called soybean, soja bean, Chinese pea and Manchuria bean, is an agricultural product of the eastern Asia. Soya bean is not only an excellent source of oils, vitamins and minerals but is also one of the richest source of protein among vegetables. Soya bean contains about 40-45 per cent protein on the dry weight basis and this amount is higher than that found in most legumes, though considerable variation of this amount may occur due to differences in environmental conditions, breed, soil fertility and nutrition. In animal feeding as well as in human nutrition, soya bean products are valued not so much for their contents of available energy—food energy can be furnished much more cheaply and efficiently by the cereal grains and flours—as soya bean protein.

The proteins of soya bean are well balanced in respect of essential amino acids (which are not synthesized in the body and hence are to be supplied along with the diet) excepting two sulphur-containing amino acids, methionine and cystine. The fortification with methionine increases the nutritive values of the raw as well as the optimally heat-processed soya beans. It has been found that optimal heat-processing increases the release and nutritional availability of the methionine content of the beans. Legume proteins are rich in lysine. So also are proteins of soya beans. They are also rich in valine.

Nutritive Values

The amino acid content of the proteins of soya bean indicates their good biological utilization, particularly the content of ten amino acids shown to be essential for the maximum growth in men and animals. In comparison with the proteins of whole egg which are completely utilized in digestion and metabolism by the growing rats, soya bean proteins being deficient in methionine have lower degree of biological utilization. Raw soya bean proteins are somewhat poor in nutritive value due particularly to the presence of a trypsin-inhibitor which interferes with the digestion by trypsin in the intestine. This trypsin-inhibitor may be destroyed by heat-processing. The nutritive value of raw proteins is improved by heat-processing and

germination, may even come up near to the standard of milk proteins and has already proved to be superior to the proteins of groundnut and cottonseed flours. The soya bean proteins are of considerable value in the feeding of infants, convalescents as well as adults. Diseases arising out of malnutrition of protein like kwashiorkor and hunger edema are successfully treated with soya bean proteins. The true digestibility of raw soya bean proteins has been found to be about 85 per cent.

Supplementary Value

Two proteins fed together often show a higher biological value than the biological value of either protein fed alone at a comparable level or the calculated value from the individual values and the proportion of each fed. This is known as supplementary effect of proteins. As wheat proteins are deficient in lysine and valine, the soya bean proteins rich in these two amino acids are effectively used to supplement wheat proteins. Hence breads containing soya bean flour have been found to be much superior in nutritive values to plain wheat breads. Similarly, the inferior proteins of maize and rye are supplemented with soya bean proteins. It has also been observed that when optimally heat-processed soya bean is significantly superior to Bengal gram in its supplementary value to the poor rice diet. Soya bean proteins are rich in lysine and poor in methionine while the sesame proteins are rich in methionine and poor in lysine. Hence these proteins are supplementary to each other and a mixture of the two in proper proportions is of immense value in practical nutrition.

Heat-processing

Back in 1917, animal experiments revealed that while animals fed diets containing raw soya bean grew slowly, heat-processing of soya bean improved their growth rate to a marked extent. Human experiments also showed that nitrogen retention in adults fed enough soya bean flour to furnish about 75 per cent of the protein of their diets is about 20 per cent greater with heat-processed (autoclaved) than with raw soya bean flour. Since soya bean flour and grit are not consumed as such but are usually cooked into some food preparations, the improvement in the nutritive value is thus ensured. Excessive heating impairs the nutritive value.

Utilization

Soya bean products are bitter, have characteristic beany flavour and taste less palatable. So during processing of soya bean efforts are made to de-bitter and remove the beany flavour and to improve their palatability. By chemical treatments these objectives have been largely achieved. Among different soya bean products mention may be made of soya bean milk and soya bean curd. Infants suffering from milk allergy can easily tolerate soya bean milk. Fermented product, soya sauce, containing pre-digested protein food is both palatable and wholesome. The Chinese preparation of soya sauce using proteolytic enzymic digestion is a household art in China and is a delicious menu of Chinese restaurants all over the world

Soya bean flour and grits are now being largely incorporated into human food preparations Breads and baked products contain some portions of

soya bean flour. The most important contribution made by the soya bean flour in breads is an improvement in the nutritive value of the products. Moreover, the use of soya bean flour improves toasting properties, the shelf life is increased with respect to staling, the bread has a rich crust colour, and it is more compressible. Up to three per cent, soya bean flour may be added to wheat flour with or without little change in formula or handling. The quality of the bread containing soya bean flour, as measured by loaf volume and crumb grain, is better than that for wheat flour alone. In the field of staple foods, macaroni and noodle products are, after bread, probably the widely used food preparations. Normally, these preparations are low in proteins. Macaroni and noodles containing a suitable mixture of wheat and soya bean flour are being prepared to overcome this protein deficiency. Some of the most desirable places to use soya bean flour are in sweet rolls, coffee cake doughs, plain, soft and devil's cakes, cookies, crackers and frozen pastry. Another most rapidly growing application of soya bean flour and grits is the use of these materials by the meat industries as a binder and emulsifier in sausages, meat loaves and similar products. Large amount of protein in soya bean flour is one of the chief attributes, since, in addition to its function as an emulsion stabilizer, its presence contributes much to the protein content of meat products. A ready-to-eat mixture of maize and soya bean flakes is available in the market. The product is a mixture of about 20-30 per cent by dry weight of solvent-extracted soya bean flakes with 70-80 per cent of yellow maize. The nutritional advantages of combining soya bean flakes having high protein content with cereal grains such as maize, rye, wheat etc., which are low in protein, are obvious. Soya bean flour is also used as an emulsifying agent in the preparation of salad dressings. The concentrated soups containing moderate quantities of soya bean flour are used as cheap protein-rich food. The isolated and modified soya bean proteins are used in place of egg albumen, as the sole aerating agent for creams, nougats, divinity, fudge and similar types of candies and confections Low starch content of soya bean flour makes it an ideal ingredient of food for diabetics.

Soya bean and its products form the principal source of proteins of hundreds of millions of the orientals and they are regarded to play a much greater role in the nutrition of these people than does wheat in the United States, or rye in Germany, Scandinavia and the USSR. Unlike the cereals, which are chiefly used in the making of breads and bakery products, soya beans are converted into numerous products which are very often substituted for such foods as cow milk, cheese, eggs and meat. To the oriental people, the soya bean proteins are essential to livelihood and cannot with safety, be omitted from their diets. The Chinese have learnt that the greatest nutritive value of the soya bean is obtained through a water extraction of its proteins. This milky liquid, after it is drawn from the residue, is coagulated into cheese. Ninety per cent and possibly even higher of the nutritive value of the soya bean is

consumed in the orient in the form of this cheese. From the nutritional standpoint soya bean flour is highly concentrated food material of high nutritive value which is best suited for use as an additive or extender of cereal flours that are deficient in proteins. The considerable importance of the soya bean as a nutrient has been known in Europe for several decades. On the eve of and when preparing for the World War II the Germany imported large amounts of soya bean from the eastern Asia and much of this quantity was converted into flour. Soya bean flour provided the Germans a concentrated food which was used in the so-called 'food-pills' which constituted the important part of the German soldiers' emergency rations. The U.S. Army also used soya bean flour in the K-ration during the War. Soya bean flour proved to be a versatile and highly successful food product in meeting food shortage in Europe and Asia during and since the World War II. Its advantage is that it meets the requirements for stability, small bulk and high nutritive values. It is estimated that soya bean flour is one of the cheapest foods available to men when judged by the amount of protein, vitamins and minerals and energy obtainable per unit of cost.

In India, there is very little cultivation of soya bean. In view of acute shortage of protein-rich foods, its large-scale cultivation in different parts of India is badly needed

Progress Against Plant Viruses

J. A. TOMLINSON

PLANTS no less than animals are vulnerable to attack by many viruses. This problem is of special importance in those commercial plants which are vegetatively propagated. But knowledge of the viruses and their mechanisms of transmission has led to successful counter-measures in many instances.

Although many virus diseases of plants have undoubtedly existed for long periods, few attracted much attention before the twentieth century. The oldest recorded plant virus disease is thought to be tulip mosaic which causes 'breaking' of the colour of the flowers. This was featured prominently in many of the paintings of flowers by old Dutch masters. As early as 1637, Dutch bulb growers knew that this character could be transmitted by grafting.

The first major advance in plant virology is generally considered to have occurred during the late nineteenth century, after Pasteur had shown that the bacterial agents of disease could be removed by filtration through porcelain filters. In 1892, Ivanowski showed that the sap from mosaic-affected tobacco plants was infective after passing through such filters. These results and the more detailed work of Beijerinck give rise to the concept of 'filterable viruses'.

It was thus with plants that the first demonstration of viruses was made. The minute size of virus particles led to speculation on their nature and, in particular, on whether they could be considered to be 'alive'.

The Structure of Viruses

Not until 1935 was any clear information obtained on the composition of viruses. In that year Stanley, using techniques of protein precipitation, made the outstanding discovery that the tobacco mosaic virus could be purified in a crystalline form. This and other discoveries about this virus demonstrated that it was extremely stable and it has, therefore, proved to be a very convenient subject for fundamental studies. Although most other plant viruses are much more readily inactivated, the research on tobacco

Reprinted from NEW SCIENTIST 30 (498) 586-588, 2 June 1966

mosaic virus has laid the foundations of an enormous volume of subsequent work.

The next major advance was the demonstration by Bawden and others that tobacco mosaic virus contained nucleic acid, and was thus a nucleoprotein. Much subsequent research has therefore been concentrated on the structure of this fascinating and complex group of compounds. The advent of the electron microscope and X-ray diffraction has greatly facilitated this work.

The size and shape of many viruses have now been determined, and it has been found that they fall into two main categories, the rods and the spheres. The rods, typified by such viruses as tobacco mosaic virus and turnip mosaic virus consist of long, straight or flexuous filaments. These two viruses have dimensions of 300 by 15 millimicrons (one millionth of a millimetre) and 746 by 13 millimicrons, respectively. Others such as arabic mosaic virus or cucumber mosaic virus are approximately spherical and are 25 to 30 millimicrons in diameter. A few such as lucerne mosaic virus, are intermediate in shape between these two types.

An important development in the use of the electron microscope followed the introduction of the metal shadowing technique, whereby it was found possible to increase the contrast of the virus particle in the microscope image and to obtain information on its profile. This was done by coating one side of the particle with a thin layer of metal. The technique showed that many of the so-called spherical viruses were not, in fact, spheres but 20-side polygons (icosahedra).

Additional and spectacular enhancement of contrast was achieved in 1959 by the phosphotungstate method of negatives staining. This method, first developed for medical work with the adenovirus, showed the virus as a clear particle against a dark background, and revealed that its surface was studded with apparently spherical protein sub-units arranged in a definite symmetry to form a capsid or outer shell. The same method has also given much valuable information about internal virus structure.

By the same means it has been found that rod-shaped viruses consist of a tube with a hole four millimicrons in diameter through the centre. With tobacco mosaic virus about 2,000 protein sub-units form a helix around the tube, and there are 49 sub-units, arranged in every three turns of the helix. X-ray studies have also revealed that there is a thin filament of ribonucleic acid (RNA) consisting of a long helically-wound strand embedded within the protein at a radial distance of four millimicrons from the tube's centre.

Purification, Infectivity

Most present-day studies on plant viruses involve attempts to concentrate and purify the infective agent. The viruses are intrinsically so different, however, that the purification techniques vary considerably. All are made easier if the infectivity of the preparations can be tested at each stage in the purification procedure.

A discovery by Hommes in 1929 greatly helped in this work. He showed that on some species of tobacco, notably Nicotiana glutinose, discrete

spots of necrosis, or 'local lesions', were produced when the leaves were rubbed with tobacco mosaic virus. The number of lesions depended on the concentration of the virus in the solution and thus provided a ready means of assessing it. In studies on plant viruses, therefore, host plants are sought which will give this local lesion effect. Such plants cannot always be found but if they are, the work of purification is often made much simpler.

For some time, the whole nucleoprotein was thought to be the basic infective unit. This idea was abandoned, however, following studies on tobacco mosaic virus by Gierer and Schramm, and Fraenkel-Conrat, who obtained evidence that the ribonucleic acid core of the virus was itself capable of initiating infection. To demonstrate this the protein sheath of tobacco mosaic virus was dissolved away by a solution of phenol. The remaining RNA was still infective, although only to the extent of one-hundredth part of the infectivity of whole virus. This and other work makes it clear that viruses consist of an infective nucleic acid core enclosed in a protecting protein sheath.

Identification

Viruses are 'obligate parasites', which can multiply only in the living host cell and, unlike bacteria, cannot be cultured in nutrient media. In the important work of detection, isolation and identification, therefore, other means have been used. One of these has been the search for specially sensitive plants—or 'indicators'—that can easily be grown, and which display a variety of symptoms when inoculated with different viruses. Several plants fulfil most of the desired requirements including Nicotiana speciesm, French bean and chenopodium amaranticolor.

In identification of plant viruses considerable use is now also made of serology. The method derives from the fact that when an animal is injected with a virus, even a plant virus, one response is the appearance in the blood of protein antibodies. Blood serum obtained from the treated animals is known as the antiserum and the antibodies in it will combine specifically with the virus. This can be demonstrated in a number of ways, one being the gel-diffusion test. In a typical experiment an agar gel is set in a petri-dish and small wells are cut in it. The antiserum is placed on one well, and a suspension of the virus in nearby wells. Virus particles and antibodies diffuse out through the agar, and where they meet a line of precipitation forms.

Previously the gel-diffusion test had been largely restricted to those plant viruses with small (usually 'spherical') particles which diffused readily through the agar. Recent work, however, has extended its use to viruses with long, filamentous particles, which can be fragmented into shorter lengths by ultrasonic vibration, whereupon they then diffuse through the agar.

As the formation of precipitation lines indicates as affinity between the test virus and the known virus to which the antiserum has been prepared, the method can often provide a ready means of identification of a virus. When used with due safeguards and in conjunction with other tests, serology is thus of great value.

Natural Transmission

Plant viruses are normally spread from plant to plant by the transfer of the virus particles occurring in the sap of diseased plants. They are often carried by sucking of biting insects, and the process may be purely a mechanical one by the transfer of infective sap on the insect's mouth parts. But in many cases the way in which transmission is accomplished is uncertain. Although the stable tabacco mosaic virus is readily transmitted by manually rubbing infective sap on the leaves and is experimentally transmissible by a species of grasshopper by the contamination of its biting mouth parts, this virus cannot be transmitted by insects with piercing and sucking mouth parts. Conversely, other viruses which canot be mechanically transmitted with infective sap are readily passed from one plant to another after ingestion by a sucking insect.

Many different vectors have been discovered, including aphids, leafhoppers, mealy bugs, whitelies, thrips, mites and certain leaf-biting insects such as flea beetles. More viruses are transmitted by aphids, however, than by any other type of insect; one species, the potato-peach aphid (Mazus persicae), is known to transmit at least 50 distinct viruses. Other aphids transmit only one or a very few viruses. Conversely, some viruses—the onion yellow dwarf virus for example—can be transmitted by more than 50 aphid species; while others, such as the lettuce necrotic yellows virus, are transmitted so far as is known by only one aphid species (Hyperomyzus lactuae).

Aphid-transmitted viruses are broadly classified as 'persistent or non-persistent' Persistent viruses are usually acquired by the aphid or leafhopper only after extended feeding periods, and afterwards the insect may continue to transmit the virus for many days—sometimes for the rest of its life. It has now been shown that some persistent viruses, for example the rice dwarf virus and potato leaf roll virus, multiply in their respective leafhopper and aphid vectors. In contrast, non-persistent viruses are acquired in feeding periods of very short duration (sometimes as short as one minute) but the insect remain infective for a few hours only.

The relationship between the virus and its vector is of prime importance in considering methods of control, especially those aimed at preventing spread of the disease by killing of the aphids. Some insecticides take some time to kill the insect, during which period the acquisition and transmission of non-persistent viruses may continue. It is often necessary, therefore, to kill the insect before it reaches the crop to be protected.

In addition to above, ground transmission, contaminated soil was for a long time known to be an important reservoir of certain virus diseases although precisely how transmission occurred was obscure until recently. It has now been shown that soil inhabiting eelworms and fungi can act as virus vectors. In 1958, it was proved that the root-feeding parasitic eelworm (Xiphinema index) could transmit the soil borne fanleaf virus disease of grapevines. Since then, other eelworm species have been shown to be vectors of virus diseases of strawberry, raspberry and potato.

There is growing interest now in the fungi as virus vectors. This has been stimulated by the discovery that the minute root-invading fungus Olpidium brassicae can transmit three viruses: lettuce big-vein virus, tobacco necrosis virus and tobacco stunt virus. In the work on the lettuce big-vein disease it emerged that the fungus alone caused no symptoms and could be transferred from lettuce to lettuce without effect. After its growth in the roots of big-vein affected plants, however, the fungus acquired the lettuce big-vein virus and the swimming spores (zoospores) of the fungus could then transmit it to healthy plants. In addition to these short-lived zoospores the fungus produced thick walled spores in the roots, which later contaminated the soil. These spores, and the virus residing within them, survived in the soil for many years and, in the presence of lettuce roots, germinated to form zoospores which re-established the disease.

Dissemination and Control

A broad distinction may be drawn between dissemination of the viruses of plants grown from seed and of those propagated vegetatively as clones. Relatively few viruses have been shown to be transmitted through the seed, although the reasons for this are unknown.

The proportion of infected seeds set by diseased plants depends not only on the kind of virus but also on the age at which the parent plant becomes infected, and on the species of plant. Thus with lettuce mosaic virus, usually two to five per cent of the seed from diseased parent lettuce plants produces infected seedlings, whereas this proportion may be as high as 80 per cent in seed from soya bean infected with tobacco ringspot virus. The growth of healthy plants of such crops demands the use of seed which is free from infection. Even with healthy seedlings, however, the plants may subsequently become infected from other sources, such as other infected crops or alternative hostplants of the virus.

Plants propagated vegetatively are subject to these hazards, but they also suffer from the fact that the viruses, being dispersed throughout the plant, are carried in the propagating material. This problem has become especially important in recent years with the development, often on a massive scale of horticulturally desirable clonal material propagated as cuttings, bulbs, tubers, crowns and root-stocks. Such material is now usually made the subject of inspection and certification schemes devised to maintain the health of the stock.

In vegetatively propagated plants found to be wholly infected, some curative methods have been developed to ensure the initial health of the stock before further multiplication. Thus the viruses in some plants have been inactivated by exposing the growing plants to a temperature of 37°C. By this means, fruit trees, potatoes, chrysanthemums and strawberry plants have been free from a number of viruses. In addition, the use of special culture technique has enabled healthy plants to be grown from such virus–infected plants as potatoes carnations and rhubarb. The method—apical meristem culture—involves the removal of the growing point (about 0.5 mm in length) and its culture under sterile conditions

on nutrient media supplemented with hormones. The regeneration of many stocks of previously desirable plant varieties which have declined in vigour, as a result of viral infection, now seems likely.

As with many other diseases, however, the ideal means of controlling viruses is the development of immune varieties. For example, potato varieties have been bred which are immune from potato virus X. Genetically controlled characters are also known which confer a high degree of resistance, as opposed to immunity. In this respect different varieties of plants may differ not only in the ease with which they become infected but also in their reactions to infection The aim of the plant breeder has therefore been to produce a variety combining immunity or resistance to the virus with highly desirable commercial qualities. By the development of such varieties, several important plant virus diseases have been controlled—such as cotton lead crinkle, sugar beet curly top, sugar cane mosaic and tomato spotted wilt.

The relatively young science of plant virology has now greatly expanded to assume world-wide importance. The subject is not only of great practical significance regarding crop plants but the study of the virus pathogens themselves throws considerable light on many fundamental biological processes.

VACUUM

S. K. SINGHAL

AIR is the basis of almost all life on Earth, but now-a-days even vacuum is as necessary as air to live. Many products of daily use need a vacuum for their working. Get rid of vacuum and everything will plunge into darkness, because bulbs and flourescent tubes will not work, preservation of food will not be possible; there will be no records, television and medicines. The possibility of creating high vacuum has made a large number of products possible.

When water is put in vacuum, it starts boiling. This technique of boiling of water is used to concentrate orange juice, grape juice, lemon juice and a new kind of instant coffee. A vacuum equivalent to 20 mile altitude, where water boils at 50° to 60°F, is created in the evaporating tanks, so that water will boil away at low temperatures. This helps in protecting the taste and flavour of these products. Manufacture of blood plasma and germ-killers also involve this technique because heating would ruin them completely. Cold-boiling is also used in purifying vitamins and other chemicals. The only difference is that in this case it is the chemical which evaporates.

Production of many other things requires absence of almost all molecules (400,000,000,000,000,000,000, molecules per cubic inch) present in a given volume of air. These would interfere with other molecules and prevent their flow. A number of coated items—lenses, automobile insignia, horn buttons interference, colour filters, mirrors for astronomical telescope and projection television sets, electrical condensers, coated toys, decorative cellophane, phonograph record, special camera lenses—are due to this technique.

Articles to be coated are put in a vacuum tank, and the material to be coated is put in the centre of the tank and heated until it vaporizes. These vapours then solidify on the article and vacuum provides easy flow which result in smooth coating. Three dimensional items are rotated by a motor inside the vacuum chamber to obtain smooth coating.

Vacuum cleaners are not only used in work-shops to clear saw-dust and chip, but also in houses. The main principle is to create vacuum in a chamber, which has an opening towards the dirty space. As air rushes in to fill

the chamber, dust, saw-dust chip and other light things go along with it in the chamber and collect there. A vessel, christened the *essayon* can note more than 8,000 cubic yards of dredged material in her hoppers using high vacuum. Vacuum pumps are also used in air-conditioners for lifting water from bottom to the top.

High vacuum also helps in metallurgical processes, providing new methods of refining and ore treatment. Some metals like magnesium, lithium, etc. react with oxygen when heated in air during extraction from their ores. But, when heated in vacuum, no oxide is formed. Titanium, a very promising metal, is a result of this high vacuum technique.

Vacuum casting is also getting prominence. Castings ordinarily contain tiny bubbles of gas trapped in the metal, which make it weak. When they are cast in vacuum there is no air to be entrapped and so the castings are very strong.

There are many products, which do not require a vacuum for production. Instead, they use vacuum as a part of their construction. Electric lamp, flourescent tube work only when air has been removed from them. Radio, television, X-ray, cathode-ray tubes involve flow of elementary particles, which are stopped by molecules in air. A thermos-flask, refrigerator, ice-bucket—all these use double walls with vacuum in between, which is perhaps the best heat insulation. A large variety of food is available in cans or air-tight packages, which maintain their freshness due to vacuum.

U-235, which is starting material of atom bombs is separated from U-238 using mass spectrometer. It sends mixed uranium particles into a vacuum tank whose α magnet curve their path. U-235 curve more than U-238 and they are collected in different collecting bins. Atom smashers, like betatron and cyclotron also require vacuum to work.

It is said that vacuum technique has just started. A great many products are under research. Milk is also condensed in the same manner and there may be other thousands of canned products. A drug store may have a number of medicines prepared by the use of high vacuum. Vacuum casting may go a step further; glass may be made in vacuum to get rid of air bubbles, and vacuum impregnation may be largely used to dye synthetic fibres. There are many things on way. What comes first and what next we have to wait and watch.

The Underwater World

G. Raju

A mighty animal of our land like the elephant, if sent down unprotected to the deepest bottom of the ocean, it will be pressed into a clean pulp of the thinness of a paper. To a layman this statement might appear to be paradoxical, curious and impossible one. But, if one understands the enormous pressure that exists in this vast and unfamiliar world beneath waves, he will understand the implications of this statement. Again he will be greatly surprised when he learns that a large number of animals live even in this world of not only high pressure, but also of eternal darkness.

The man gets the credit of having struck with a beam of light the floor of the ocean—the region to which even the sun's rays did not succeed in penetrating. Man could go to this part of the ocean for the first time only in the year 1960. One might wonder as to why man with all his oceanographical research stations set up at different parts of the coastal regions of the world and the various oceanographical expeditions organized from time immemorial, succeeded in this adventure only in the year 1960.

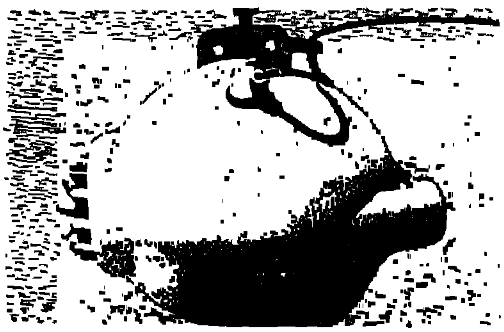
The answer lies in the peculiar nature of the domain—the deep sea. As one goes down, the pressure increases by one 'atmos' (1.0336 kg. wt./sq. cm.) for every 10 metres' increase of depth. At the depth of 11 km. an object with the surface area of one square metre will be subjected to a pressure of nearly 11,370 metric tons. Even the modern nuclear submarines which can operate normally at 275 metres below the sea level would crumble at 900 metres like an empty match box under the sledge of hammer. Thus it is more difficult to descend even one kilometre into the sea than to ascend up a similar height in the air.

Conquest of the Deep

Let us find out how man by his sustained effort during the last thirty years succeeded in reaching the floor of the ocean trench lying at a depth of 10,911.5 metres below the sea level. Due to increasing pressure with the increase of depth and the capacity of lungs to hold limited amount of oxygen, divers cannot go beyond a certain limit. The greatest depth reached by a machine diver was 93 metres and a diver in an armoured suit had reached 159 metres.

Bathysphere

The earliest actual beginning of descending to the bottom of the ocean was made in the year 1930 by two American explorers, William Beebe and Otis Barton. They designed a hollow diving ball called bathysphere in which they could sit and observe the life in the sea through the window of fused quartz. The bathysphere was a ball of chilled cast iron of 1.37m in diameter with its walls 4cm in thickness and the whole ball weighing 2.5 tons. The bathysphere was lowered and raised by means of a steel cable from the side of a research vessel. The bathysphere also contained calcium chloride for absorbing moisture, oxygen cylinders for breathing and soda lime for absorbing

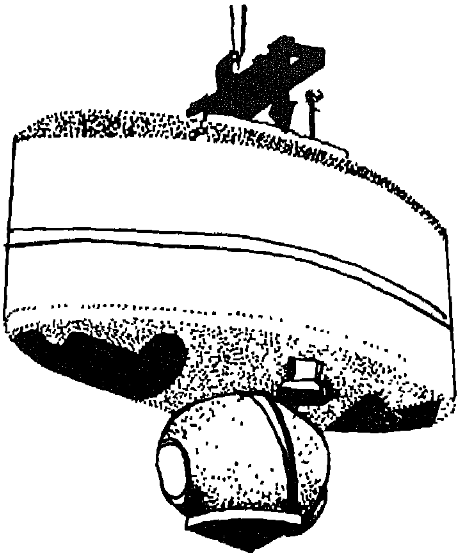


Bathysphere

excess of carbon dioxide. The two men sitting inside were connected to the men on board the research ship through a telephone.

In 1930 they reached a record depth of 425 m. They made further attempts and reached a depth of 910m in 1934. Then the Second World War broke out and disrupted their plans.

They found that at a depth of about 45m red rays became invisible to the human eye. At 180 m only a pale twi-



Bathyscape

light was seen and between that and 550 m where the last trace of light vanished, there was a steadily deepening blue light.

Bathyscope

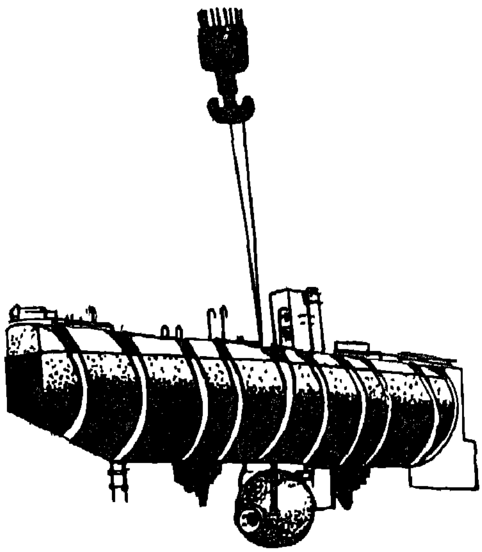
Otis Barton constructed another steel sphere on the same model as the bathysphere. He called it bathyscope and reached a depth of 1,365 m in the year 1949. The disadvantages of the bathysphere and bathyscope were that they were swinging backward and forward like a huge pendulum at the end of steel cable and rotated around its own axis. These made the observations of marine life outside, extremely difficult. The operating of the diving ball from a vessel created certain additional problems. Therefore the explorers began to think about mobile, self-propelled deep-sea vessels.

Bathyscape

French naval officers George S. Hout

and Pierre William began to descend into the depths with bathyscapes which were quite independent of the surface. They could descend and explore up to a depth of 4,068 m. The most prominent role, for the development of modern deep sea diving apparatus, was played by the Swiss physicist Auguste Piccard. He designed a bathyscape named *Trieste*. It consisted essentially of two parts, the float and the cabin. The float consisted of 14 chambers, 12 of which were filled with petrol and one at each end with air. The cabin weighing ten tons was 1.40 m in diameter with the wall about 18 cm in thickness. Its petrol (which is lighter than sea water) provided the necessary lifting power. One hundred and fifty kilolitres of petrol gave the vessel an upward lift of 125 tons.

The bathyscape could be made to sink by flooding the air tanks with water. As it goes down the petrol in the other tanks becomes compressed



Bathyscope

at a greater rate than the sea water under the same pressure, but openings into the tanks on the under-surface allow water to enter. This makes the pressure inside equal to that on the outside. As water enters, the petrol, being lighter and unable to mix with it, floats on to the top of it. Two propellers are operated by batteries and they drive the ship horizontally after it is submerged. The descending was done by releasing some petrol. As petrol is replaced by water flowing in through the openings at the bottom of the float, the weight of the bathyscape increases and it submerges at the rate of about 18 m per minute. The ascending is done by releasing the rest of the ballast which makes the bathyscape lighter than the water it displaces.

The cabin was equipped with an echo sounder, an acoustic telephone, equipment for generating oxygen and absorbing carbon dioxide. There was a plastic window in the cabin illuminated by mercury vapour flood lights for the men in the cabin to observe the nature of the sea and the animals living there.

The historical trip on reaching the bottom of the deepest trench of the Pacific Ocean—Mariana Trench was undertaken by Jacques Piccard, son of Auguste Piccard. Mariana Trench is in the Pacific Ocean 10,911 m below sea level. A mountain as high as Mount Everest could disappear in this abyss and if a structure 20 times the height of Qutub Minar were added to it, the tip would still remain hidden some 620 m beneath the waves of Pacific. The pressure at this region is 11,278 k.gm./sq. cm. The pressure acting on the vessel on the whole at this depth was about 120 thousand tons. On 23 January 1960,

the young Swiss scientist Jacques Piccard and the U S. naval officer Donald Walsh reached the bottom of the Mariana Trench. They took 4 hours and 42 minutes for descending and spent about half an hour exploring the area through the plastic windows. They spotted a red shrimp measuring about a centimetre and a fish looking like a sole of about 30 cm in length. What remarkable adaptations, these tiny living creatures should have to withstand the tremendous pressure of water acting on them !

DEEP SEA LIFE

What do these explorations reveal about the nature of life in such deep areas? Life in the ocean depth is very much different from that at the surface. These changes are not abrupt from one region to another but are gradual.

Thinly, Populated Dwarf Creatures

In certain respects the deep sea can be compared to the deserts of the land. As we go deeper in the ocean, less and less of animals come in our hauls. This clearly indicates that life becomes scarce with the increase of depth. This is true not only for larger animals, but also for the microscopic animals that largely constitute the plankton. The term plankton refers to living things that passively drift and are at the mercy of ocean currents. Apart from the scarcity of animals, there is a decrease in their size as the depth increases. Indeed so marked is their small size that the famous Norwegian oceanographer, Johan Hjort, called the deep sea animals the Lilliputian Fauna.

Unending Food Scarcity

The scarcity of animal life in deep sea is mainly due to the availability of very little food. Both on land and in sea, all animals depend either directly or indirectly upon plants for their food. In the sea, the plants like algae are the basic links in the food chain. These algae can manufacture their food and thrive only in such places where sufficient amount of sunlight is available. Since sunlight does not penetrate into the deep sea, algae are absent there. The organisms living there are mostly carnivorous depending upon other animals for their food. This acute food problem is reflected well in the fishes which are well adapted to obtain food. Many deep sea fishes have wide gaping mouths. In some fishes the jaws are nearly one third the length of the body. These large mouths help the fishes in swallowing their prey which are sometimes twice their own size. The food is swallowed whole. Their stomachs are highly elastic to accommodate such large-sized preys. In order to prevent their prey from escaping out of such wide mouths the latter are armed with sharp, recurved teeth.

Coupled with large jaws and teeth, we find that many of the fishes carry lures or baits apparently for bringing the prey within reach of the jaws. Such fishes are called angler fishes. On the top of their head one or two spines are directed forwards bearing a small fleshy lobe. To put it in 'anthropomorphic' terms, small fishes seeing the lobe waving, approach them to examine them out of curiosity. At the appropriate moment the huge jaws beneath snaps and the small fishes find themselves inside the mouth of the angler fish. Such angler fishes are also found in surface waters. The deep sea angler fishes carry a small

luminescent organ at the tip of its fleshy lobe. Since the deep sea is dark, these wriggling light tags attract the fishes to come near them.

Bioluminescence

Another characteristic of many deep sea animals, is the possession of light organs. Since the deep sea by itself is eternally dark, some of the animals like the fishes, squids, octopuses, prawns and tunicates carry their own light. The light organs are of many kinds and patterns. In deep sea squids and octopuses, the light organs are numerous (sometimes about 150 in number) scattered all over their body. In fishes, they are larger in size and are often arranged in groups. The pattern of light organs is often characteristic of a species —all members of the same species possess the same pattern. It is reasonable to suppose that members of a species will recognize each other by the pattern of lights moving in darkness. This will be one way in which the males and females would find each other during the breeding season.

Though many deep sea animals are found to carry light organs, the way some of these animals use the light is still a mystery. Some blind fishes carry light organs. We do not know as to how the lights are useful to them for the recognition of their own members. Again in certain others the light organs are found on the inside of the mouth or in certain internal parts like the liver. Many deep sea fishes carry the light organs within their eye balls. Perhaps they make use of their light to focus on their prey. Some deep sea prawns and squids use light for their defence. When attacked by an enemy, they throw out a luminous cloud, just as squids living near the surface squirt ink to confuse their pursuers. A cloud of ink in regions of eternal darkness would be useless, but a blaze of light will dazzle the attacking animal and provide a chance to the victim to escape.

We have seen that many deep sea animals possess light organs. These animals with a few exceptions often have large eyes to recognize the patterns of these light organs. The enormous and often saucer-like eyes enable these animals to see clearly their environment which are lighted only with faint light of the luminescent organs. There are again fishes in the same region which are either completely without eyes or have only tiny remnants of eyes. The blind fishes are very sensitive to vibrations in the water. One of the striking feature of the deep sea fishes is that most of them carry 'feelers'. These are often long barbels from the chin sometimes highly branched or unbranched but long and threadlike measuring five or six times the length of the fish. The feelers are often considered as organs of touch and even of taste.

Males Parasitic on Females

The breeding habits of some of the angler fishes reflect the thinness of the population and the problem of finding their mates in deep sea. The females of some of these angler fishes are about one metre long while the males are not more than 10 cm long. Although the adults live at great depths, the young ones ascend up to the surface waters and feed on the plankton. After they grow to a certain size, they descend down into the deep waters. The females grow

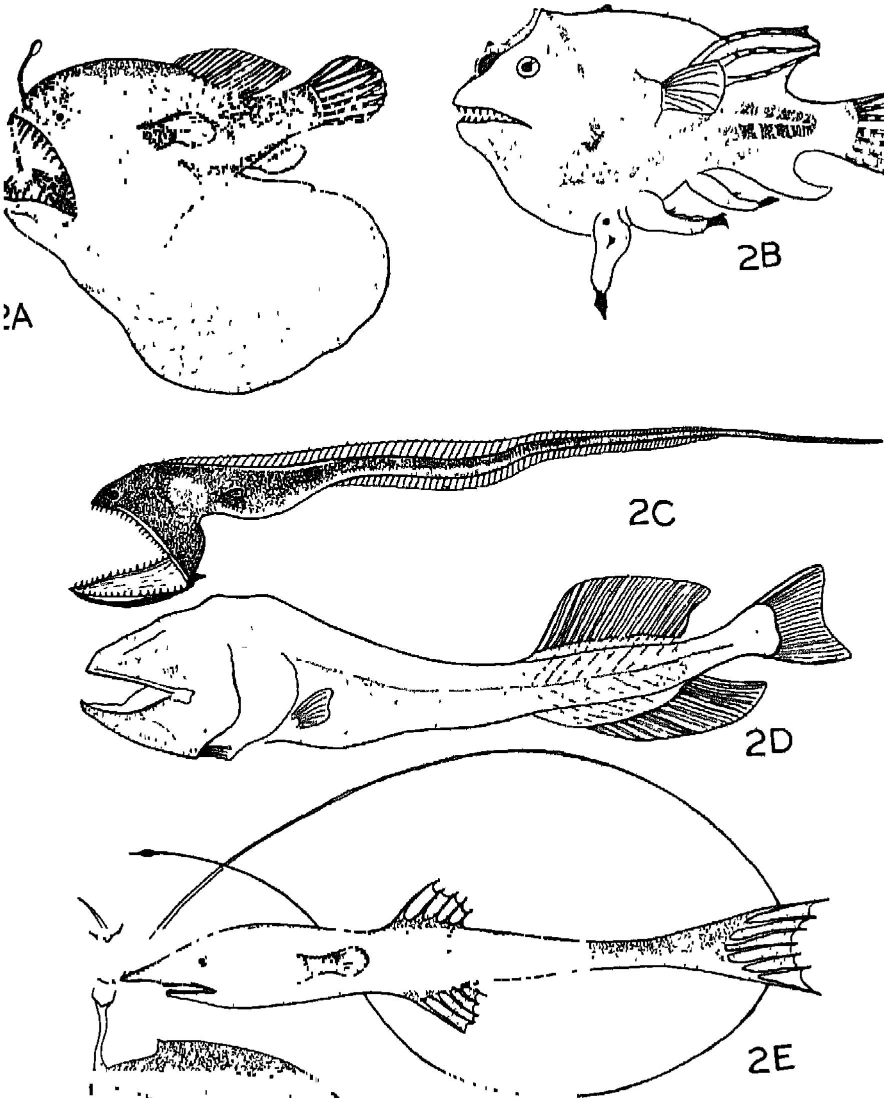


Fig. 2A A deep sea fish with its stomach gorged with prey bigger than its own size.

Fig. 2B Deep sea female fish to which males are attached.

Fig. 2C Other deep sea fishes showing wide mouth, long feelers.

Fig. 2D Sharp recurved teeth and lures to attract prey.

fat and round while the males are slender with large eyes and special teeth on the snout. The males go in search of females. As soon as a male finds a female, it immediately seizes it by the skin and gets attached to any part of the body with which it comes in contact. From this day the male starts its parasitic life on the body of the female. The skin of the male fuses with female, leaving a hole on either side if its head to allow for breathing. The digestive organs of the male shrivel away and its blood vessels join those of the female. The male is nourished by the blood of the female. The purpose of the life of the male is reduced simply to fertilize the eggs. Male becomes merely a small bag-like appendage carrying the reproductive organs inside it. Such an adaptation as this avoids the searching out of its mate at the time of the breeding season.

Fragile and Lightly Built Body

In deep sea, there is very little movement of water. The changelessness of the environment is a remarkable feature at ocean depths. The march of seasons are not at all felt there. Hence there is no need for fishes to have powerful build of muscles or strong fins which are often adapted to overcome the resistance offered by the strong currents of water The bodies of deep sea animals are often fragile and lightly built. This is well seen in deep sea octopuses and fishes. Deep sea octopuses, in contrast to their relatives found in surface waters, have jelly-like bodies with webbed tentacles. They can easily be mistaken for a jellyfish. The body of deep sea fishes is often either slender with a long tail or laterally compressed as in the hatchet fishes.

Dull Colourless World

Another characteristic of the deep sea fauna is the absence of colours. Normally in the surface layers, fishes, prawns, octopuses and other animals are highly coloured and many fishes are blue or green at the back and silvery below. Fishes found at depths 145 to 180 m, where there is a perpetual twilight are silvery all over their body. From 180 to 1,800 m there is very faint light and the fishes have black coloured body. Other animals in these waters though mainly transparent become darker and predominantly red in colour beyond 450 m From 1,800 m and below where there is eternal night the fishes are either uniformally black or colourless and transparent.

The floor of the deep sea is a semi-fluid mud. It is formed of a bottom ooze. There is the danger of heavy animals getting sunk in them. The deep water animals in addition to being small, often have long appendages. Crabs and prawns for example, have long legs. Sea-spiders have the main body of about a centimetre in length but legs of more than ten centimetres long. Sedantary animals—animals that remain stationary in one place—have long stalks and rafts. Sea pens have stalks embedded in the mud, holding their main body high in the water. Sea-lilies also have very high stalks bearing the body well above the bottom sediment. Many of the deep sea sponges are stalked or have the body seated on a raft of long tangled glass threads or spicules. In addition to long appendages, stalks and rafts to

keep the deep sea animals from sinking into the ooze, a number of other adaptations are found in different animals for achieving the same end. One deep sea octopus has a flattened body like a parachute with short and stout tentacles. Deep sea starfishes have flattened bodies with long slender arms; sea-urchins have long slender spines. All these structures help these animals from getting sunk into the soft sediment.

How are the deep sea animals able to withstand the enormous pressure acting on their bodies? This is still a mystery with regard to many groups of deep sea animals. But we know how the fishes are adapted for this. Fishes have an organ called swim bladder. This may be of different shapes and sizes in different fishes. They help the fishes to swim at different depths. Deep sea fishes secrete a gas inside the swim bladder. The pressure of this is kept equal to that acting on their outside bodies. Some deep sea fishes swim up to considerable distances in search of food. These are able to alter and adjust the pressure inside with that acting on their bodies at different depths. Sometimes certain fishes that cannot adapt themselves to the changing pressures, attempt to swim up. As it rises, the water pressure acting on them decreases and this causes the gas in the swim bladder to expand and the fish rises up against its wish. As it gets near the surface, the organs inside the fish swell up and the fish dies bursting like an over-inflated balloon.

The temperature of the water at great depths is below the freezing point and yet the fishes do not freeze to death. Recent experiments conducted in the laboratory showed that fishes would remain alive in super-cooled water until they came into contact with ice crystals. Then crystals are formed within their bodies and they freeze to death. But in deep sea water ice crystals never form, even though the temperature is below the freezing point. The great pressure lowers the freezing point and prevents the formation of ice crystals.

Thus the deep sea world is a strange one—it is one which is very difficult to imagine. Many of its aspects still remain a mystery to man. It is the hope of the marine biologists and oceanographers that in future better equipment for studying the deep sea will be available and many enthusiastic 'hydronauts' will take up the challenge and clarify the prevailing mysteries of the deep sea and its life.

Classroom Experiments

A Simple Chemistry Kit

M.C. Pant, N.K. Sanyal
and V.A. Glushenkov

CHEMISTRY is an experimental science and the most enjoyable part of it is experimentation Laboratory experiments are very important for a better understading of the theoretical and practical aspects of chemistry by the pupils. These laboratory experiences add reality to the text material, develop a first-hand familiarity with equipment, materials and techniques, allow the students to demonstrate things that are already known to be true and give them an opportunity to seek answers to their problems by designing expriments to test their predictions. These laboratory experiments go a long way to help the children to acquire the basic laboratory skills which are very important in any programme of chemistry teaching.

The main defect with our teaching of science today at the middle stage is that the children are hardly allowed any opportunity to do experiments by themselves or are shown demonstrations by the teachers. One of the reasons for this is the shortage of laboratories and equipment.

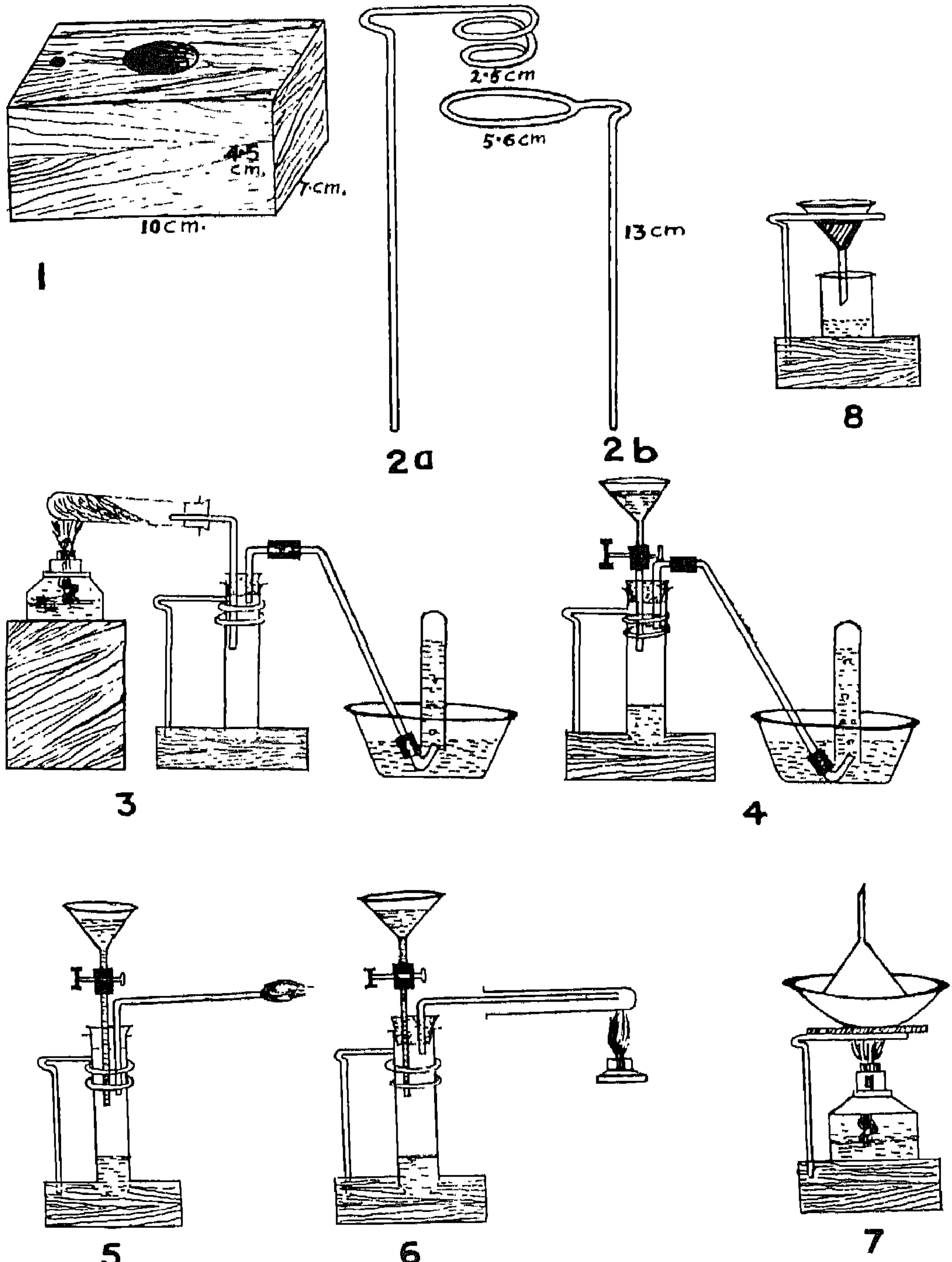
With a little planning and resourcefulness on the part of the teacher it is possible to provide a number of simple laboratory experiences in chemistry to the middle school students even in the ordinary classroom by making available simple kits.

This kit can also be used by the teacher to show a number of demonstrations, but the effective use of this could be made by allowing the pupils themselves to perform a number of simple laboratory experiments which generally find a place in a regular chemistry programme for middle schools.

Description of the Kit

1. A wooden block 10 cm × 7 cm × 4.5 cm. It has two cylindrical depressions one big (2 cm deep and 2.5 cm in diameter) at the centre of the broad face and the other a small one (3 cm deep and about 3 to 4 mm in diameter) at one side of the same face about 3 cm away from the big depression. These depressions are scooped out of the wooden block (Fig. 1).

2. A spiral support made of iron wire of about 3 mm diameter. The spiral has a diameter of 2.5 cm and is bent at an angle of 90° so that the length of the knee of the spiral is about 17 cm (Fig. 2a).



Various parts of the chemistry set

3. A ring support made of similar iron wire used for making the spiral. The diameter of this ring is about 5 to 6 cm. and the ring is also at an angle of 90° so that the length of the knee of the ring equals about 13 cm. (Fig. 26).

4. Two glass tubes bent at right angles with the length of each arm being 4 cm.

5. Two glass tubes bent at right angle with one arm of length 4 cm and the other of 16 cm.

6. A glass tube bent at right angle with arms of length 10 cm and 4 cm. The 10 cm arm has a nozzle at its end.

7. A glass tube 14 cm in length.

8. A glass rod of about 17 cm in length with a small rubber cap (made out of rubber tubing) at one end.

9. Two glass tubes bent at an angle of about 45° with length of 2 cm. each.

10. A glass funnel of diameter 6.5 cm.

11. Two boiling tubes of standard size (15 cm × 2.5 cm).

12. Six test tubes of standard size (15 cm × 2 cm).

13. One 100 ml beaker and one 50 ml beaker (Borosil).

14. A beaker cover of 12.5 cm diameter.

15. A medicine dropper.

16. Small deflagrating spoon.

17. A collapsible test tube stand.

18. A test tube holder.

19. A small school type metallic spirit lamp.

20. Asbestos-covered wire gauze (small size).

21. A small porcelain or enamel dish (diameter of about 10 cm).

22. One pinch-cock.

23. Three pieces of rubber tubing each of 3 cm length to fit with the glass tubes and one spare piece of rubber tubing 10 cm long.

24. Following types of rubber stoppers:

(i) One stopper No. 7 size with one hole; (ii) one stopper No. 7 size with two holes; (iii) one stopper No. 2 size with one hole; and (iv) four stoppers of No. 2 size.

25. Twenty-five filter paper circles of 10 cm diameter.

26. Blue and red litmus paper books — one each.

Use of the Kit

With the help of this kit it is possible for students and teachers to do a number of laboratory experiments which generally find a place in a middle school chemistry programme, *e.g.*, for preparing oxygen, hydrogen or carbon dioxide and studying their properties, we can assemble the various parts of the kit as shown in Figs. 3 and 4. Other experiments which can be shown are the burning of hydrogen gas (Fig. 5), the reducing property of hydrogen gas by passing it over copper oxide taken in a boiling tube (Fig. 6), the crystallizing of common salt or the study of the sublimation of iodine Fig. 7) and doing filtration (Fig. 8). It would thus be seen that this kit would be sufficient to provide simple type of individual laboratory experiences to the children and develop in them the necessary experimental skills. Another advantage of this kit is that very small quantities of the chemicals would be needed for performing the experiments, thus effecting a considerable saving in both money and time. With variations, a number of other experiments can also be organized by the class teacher.

The whole kit can be conveniently packed in a wooden box of 30 cm × 25 cm × 10 cm with partitions. The above kit can be easily prepared in the school itself if there is the facility of a small school workshop or wood working class. The glassware can easily be bought from the market. The cost of the kit would roughly come to about rupees twenty.

REFERENCES

1 DUBNIN, F. A. *Chemical Study Room at Secondary School.* Academy of Pedagogical Science, USSR, 1962

2. PAGUR, S. I. *Chemistry at School Methods.* Journal of the Ministry of Education, USSR No. 2: p 68, 1966.

3. VERKHOVSKI, V N. *Techniques and Methods of Chemical Experiments at School,* Uchpedgis, Moscow, 1960.

Science Abroad

Science Subjects in School Curriculum

I. D. Zverev

HUMANITY has accumulated a voluminous knowledge of nature, known as science. A great variety of natural bodies and phenomena under study, and their systematic organization have led to the creation of a number of independent sciences, which at the very beginning of the accumulation of forming scientific knowledge constituted a common physics, the science of nature. Recently, there has appeared quite a number of new branches of independent natural sciences. Physics, for example, is divided into classical physics and quantum physics. In their turn they consist of mechanics, molecular physics and electrodynamics. Theory of relativity constitutes an independent branch of physics

Chemistry also consists of a number of branches: inorganic, organic, physical, analytical, colloidal, etc.

Knowledge of the living has built up an extremely complicated system: botany and zoology are main in this system. These sciences in their turn consist of morphology, anatomy, histology, physiology, embryology, ecology, taxonomy, palaeontology, etc Physiology of the human body forms an independent science. It may further be divided into a number of concrete branches of science. A significant role is attached nowadays to microbiology, cytology, genetics, theory of evolution, etc. All these are branches of biology and are closely correlated between themselves and with other adjacent sciences

A systematization of sciences is based on the correlation of phenomena. This thesis is proved by the following example: mechanical motion of a molecule is closely interwoven with thermal phenomena; the motion of charges conditions electomagnetic phenomena, which may result in chemical transformation of protein—the bearer of life. formation of protein the bearer of life. Thus, due to the correlation of a number of phenomena, physics, chemistry and biology are correlated too.

Natural sciences reflect objective laws of nature, thus conditioning correlation of bodies and phenomena in nature. Accordingly, all the adjacent sciences are closely interwoven and this is well proved by the development of scientific knowledge at the junction of sciences. Mutual penetration of

scientific knowledge is reflected in the appearance of neighbouring sciences, *e.g.*, geophysics, biophysics, physical chemistry, bionics, biometry, cybernetics, etc

Science is closely linked with practical, *e.g.*, physics and chemistry deal with the theoretical basis of production of materials, instrument-making, machine-building, etc., biology for medicine, agriculture, nutrition, etc. The application of scientific knowledge leads to new problems for which solutions are constantly being sought by scientific research.

The above system of sciences should determine the system of school science subjects as a systematized knowledge of physics, chemistry, biology, etc

Pedagogical Concept of Correlation of Subjects

To avoid the possibility of isolating the various school science subjects as physics, chemistry and biology, it is necessary to bring in the interconnection of the knowledge of these fields. This can be brought about by a constant correlation of these subjects.

This correlation of subjects can be effected by:

1. Emphasizing the universality of the leading ideas of science in its various disciplines, *e.g.*, we know such fundamental laws of science as the laws of conservation of mass and energy. In physics, the universality of the law of conservation of energy is proved by the following example:

The initial research of b-decay proved that the energy of the atom before decay is more than the energy of the new atom and the energy of the newly formed electron. A further research of this phenomena, which seemed contradicting this law, had led to the discovery of a new particle *neutrino*

It turned out that the energy of the atom before decay is exactly equal to the energy of a newly formed atom, the energy of an electron and the energy of a neutrino. Thus, the correctness of the law of conservation of energy has been proved. At the same time a number of other phenomena (*e g*, decay) broaden our idea of this law, thus emphasizing the possibility of mutual transformation of substances and energy and the fact that energy neither disappears nor appears, but is transformed in equivalent quantities from some form into the other. Much is said of this in the course of chemistry when the teacher shows that the weight of the substances entering a reaction is usual to the weight of the substances formed as a result of the reaction. In biology, this law can be illustrated by the following example:

The quantity of energy and substances consumed by a green plant is equal to the quantity of the formed mass and energy (here are meant experiments in photosynthesis with due regard for the amount of the energy absorbed by green plants and discharged in the process of their burning).

Thus physics, chemistry and biology give innumerable examples of proving the laws of conservation of mass and energy and, consequently, the universality of this law.

2. The correlation of the science subjects is also reflected in the use of special science concepts and facts in the related science subjects, *e g*, the concepts and factual knowledge of chemical elements, types of reactions etc., are obligatorily

referred to while studying the cell composition, metabolism and respiration. The biological concepts relating to the role of oxygen in the life of an organism is mentioned while explaining the oxygen exchange in nature and revealing full characteristics of its physical and chemical properties in a lesson of chemistry.

3. Application of the same methods of research in the course of examining the phenomena in various sciences, *e.g.*, physical and chemical methods are employed to examine the functional processes in the organisms. Electric and electronic equipment (electronic microscopy) facilitates the comprehension of the most complicated mechanisms of the life of a cell tissue, organs and organism as a whole. Studying of the functions of cell and organism is based on biochemical analysis.

While mapping out the contents of any school subject, one should always bear in mind the proper time for introducing these concepts and facts which are necessary for building up and developing knowledge in some other school subjects. This is an extremely difficult and responsible task.

While introducing any change and improvement in the content of natural science education, one should take into consideration the correlation of school subjects, *e.g.*, elementary idea of the composition and properties of water and air is introduced in classes IV and V. thus facilitating studying the functions of plant and animal organisms (botany and zoology); later on this elementary idea helps pupils to study more profoundly the properties of oxygen, carbondioxide gas, etc. It is very important to determine what knowledge is common for these school subjects; when and in what subject this knowledge should be introduced; what should be the methodical ways of reciprocal employment of correlation links in these school subjects.

Correlation of subjects should be based on a reciprocal agreement of the content of all the science subjects, *e.g.*, explanation of the function of an air bladder, in class VII is possible due to pupils' knowledge of Archimedes principle studied earlier in class VI. A graph of the solubility curve of salts studied in the lessons of chemistry in class IX can be easily comprehended by pupils in case they have mastered the notion of functions in lessons of mathematics in class VIII.

The idea of proportion (class VI) is widely used for finding the percentage of substances in solutions, calculating the percentage of substances by formula (class VII) and equations in the course of chemistry (class VII).

The concept of catalyst lays a good foundation for revealing physiological concept for fermentation in the course of anatomy, physiology and hygiene of man in class VIII.

To facilitate pupils' comprehension of the physical laws, it is necessary to refer to their knowledge of mathematics. On the basis of graphs, concrete physical phenomena can be described mathematically. The application of mathematical knowledge in studying mechanics (class IX) in the lessons of physics has resulted in the introduction of the new theme *vector* in the course of physics. Here are some other examples:

Correlation of physics (class VI) with science subjects.
In the theme "Physical phenomena"

Knowledge of physics	Knowledge of the school subjects referred to
1. Physical quantities	1. Measurement of length and volume (mathematics)
2. Precesion of measurement weighing	2 Rounding off. Approximate calculations (mathematics)
3 Graphic expression of force	3 Construction of segments of given length, scale (mathematics)
4. Specific gravity	4. Volume of rectangular parallelopiped. Volume of a cylinder, area of a rectangle. Area of a circle. Division (mathematics)

Correlation of chemistry with other school subjects:
In the theme "Elementary information of structure and composition of substances"

Knowledge of chemistry	Knowledge of the other science subjects referred to
1. Atom-molecular study	1. Brownian movement, impact of temperature and pressure on the movement of molecules, change of state, expansion etc (physics)
2. Metals and non-metals	2 Physical properties of solids (physics)
3. Distribution of most important chemical elements in Nature	3. Mountains, rocks and minerals (natural history)
4. Calculation of the percentage composition of substance by its formula	4. Calculation of percentage. Proportion (mathematics)
5. The role of M. V. Lomonosov in the development of chemistry	5. Versatile activity of great Russian scientist M V Lomonosov in the sphere of science, art, literature

There exist certain objective difficulties in effecting a correlation of subjects which are beyond the means of the teacher. It is not always that previously acquired knowledge of other science subjects guarantees the teaching of the main system of concepts in any subject. These difficulties may be overcome by changing the order of introducing separate themes; adding concepts borrowed from other science subjects, e.g., certain problems of chemistry are included in the course of botany (classes V and VI), elements of astronomy in the course of physics (class VIII, solar and lunar eclipses, etc.)

In some cases the studying of more complicated concepts is shifted to senior classes when pupils get a more sound basis for comprehension of ideas and are equipped with the knowledge of other science subjects, e.g., electrolytic dissociation (chemistry in class IX is introduced after the study of the structure of atom and the theory of atomic and ionic bonds; complicated physiological concepts of cellular metabolism, biological role of reflexes, appearances of life on earth are taught in the lessons of biology in class IX.

In this paper it is not proposed to discuss all the cases of correlation of natural science subjects. But nevertheless we can already see the variety of these bonds. They stimulate building up the system of flexible knowledge, that is, the knowledge which pupils can employ in various school conditions and in practical life.

Correlation of subjects stimulates forming pupils' world outlook, promoting their general mental development and comprehension of the bases of sciences in each school subject.

For the sake of strictly keeping the correlation between subjects, a teacher should:

1 get acquainted with the syllabi of all the school subjects;
2 pick out the leading ideas for the revealing of which the teacher should utilize the correlation between subjects,
3 take into consideration pupils' knowledge of other subjects;
4 coordinate with his colleagues ways of overcoming the difficulties due to poor correlation between subjects.

General Science and Correlation of Subjects

At the lessons of general science, pupils also get acquainted with variety of objects and phenomena. But the structure of this course greatly hinders the building up of a systematic knowledge of nature for the pupil. The main shortcoming of general science lies in its presenting a complex of various problems having no harmonious structure as a whole.

General science contains interesting material, well illustrated and full of facts. But the main shortcoming is characteristic of all the syllabi and textbooks in general science that they are mostly composed of isolated themes. Pupils in each class study independent fragments from the field of physics, chemistry, biology, and astronomy and it is very difficult to establish any bond between these fragments.

The Syllabus in General Science (New Delhi 1963) for class VII contains: air, rocks, soils and minerals, respiration and circulation, excretion,

housing and clothing, energy and work, etc. We see that all these themes cannot build up a systematized content that is characteristic of a discipline

Eclecticism of general science syllabi is acknowledged by its champions H. R. Saunders considers: "The greatest and most damaging criticism of a general science syllabus is that it is all 'bits and pieces', 'bits and pieces' of knowledge of various scientific fields cannot replace knowledge of the bases of science in such school subjects as physics, chemistry, biology, etc."

At first sight it may seem that general science envisages correlation of natural phenomena, but absence of logical bonds between separate parts of this school subject objectively makes it difficult to realize it.

It is worth mentioning that the attempt of *the General Science Syllabus* (New Delhi 1963) is to display the development of separate problems by units (from classes I to VIII).

But still there are two essential shortcomings.

1 The problems and trends determining the formation of scientific knowledge in each class are far too numerous.
2. Difficulty of systematization of knowledge due to its absence of coordination.

After all, these 13 units may be systematized as the following school subjects: geography, biology, chemistry, physics, and home science. All the parts of general science complex are separated and, at the same time, unified.

Correlation of subjects may be established in the process of studying the bases of sciences. They may be done by introducing the knowledge gradually and then bringing the more complicated themes so that all the themes and units of various subjects are closely interwoven and systematized.

REFERENCES

1 H R Saunders, "The Teaching of General Science in Tropical Secondary Schools", London, Oxford University Press, 1963, p 26

2 *General Science Syllabus--Classes I-VIII*, NCERT, 1963

Teaching of Chemistry in Asia

L.E. STRONG

IN September 1965 a project was begun to develop new materials and methods for secondary school chemistry. UNESCO, through its Science Teaching Division, established the project and supplied a major share of the financing. Through a generous offer of assistance from the Thai Government, the project headquarters have been established in Bangkok at Chulalongkorn University. Invitations to participate were issued to all Asian nations who are members of UNESCO. Twenty-two participants have assembled under the leadership of Dr. M. Shafqat Siddiqi, Professor of Chemistry at Peshawar University, Pakistan and Dr. Laurence E. Strong, Professor of Chemistry, Earlham College in the USA. The countries represented are Israel, Afghanistan, Pakistan, India, Ceylon, Burma, Thailand, Malaysia, Philippines, Republic of China, Korea, and Japan.

The Pilot Project is scheduled to operate through July of 1965. In this period material will be developed for two or three topics that could be useful parts of a secondary school chemistry course. Once developed these materials will be made available to groups in the participating countries for trial and evaluation. Although the international nature of the project has made English seem the best madium for operations, it is hoped that suitable translations will be made in the participating countries.

The student laboratory work in chemistry needs to be revitalized and made more central to the instruction process. To this end, the main efforts of the Pilot Project are directed towards the development of new laboratory experiments, supported by appropriate directions for students and interpretation for teachers. In addition, questions, problems, and short films will be fitted together so as to provide students with material sufficient to permit them to draw significant conclusions. It is intended that the course material will acquaint students with chemistry as a method of inquiry. Therefore the main attention will be to the problems of the acquisition and the interpretation of data.

There are several facets to the work of the Pilot Project. First, the subject matter of each topic will be analyzed in sufficient detail to be sure just

what is the nature of the chemical problems to be presented to the students. Second, the activity desired of the student will be worked out in detail. Third, a teaching programme will be devised, adequate to produce the desired student behaviour. Fourth, the teaching programme will be tested on students to find out if the several steps lead to the desired alteration in student behaviour. When it is demonstrated that the course materials are suitable, kits will be produced and made available to participants for use in their own countries.

The first topic selected for development is that of stoichiometry. It may come as surprise to chemistry teachers that this topic could be profitably analyzed beyond what has long since been customary in textbooks. However, when one examines the presentation made even in the best textbooks certain difficulties become evident. It is quite common for students to study the reaction of a metal such as iron with sulphur as an example of a chemical reaction. Evidence that a chemical reaction occurs is obtained by showing changes in magnetic properties, in colour, in temperature, and solubility. Yet if one asks just how these property changes are evidence of chemical reaction, there is not a very convincing answer. Certainly there are many reactions known where most if not all of the changes observed for iron and sulphur do not occur. Further, several of the changes observed for iron and sulphur can be produced in interactions which would hardly be regarded as chemical reactions. So one must conclude that the changes to which the students' attention is called are neither necessary nor sufficient for indicating the underlying nature of chemical reaction.

Through discussions among the participants in the Pilot Project we have drawn some conclusions about the general characteristics of a chemical reaction. In a reaction between two substances that are mixed together, a product is produced whose properties are distinctly different from the initial reagents. This difference in properties is not altered by changes over a considerable range of the initial ratio of reagents. If the total quantity of the reagents is kept fixed while the relative amounts are altered, then it is found that the quantity but not the properties of the products change. By contrast when the mixing of two substances results in a solution rather than a reaction it is found that the total quantity of solution remains constant but its properties alter as the relative amounts of reagents are altered. It would seem that it is these generalizations that need to be encouraged by adequately designed experiments if students are to proceed effectively in their study of chemistry. Work along these lines is going forward at the present time.

The services of several consultants have been obtained. These include:

Frank Halliwell, Reader in Science Education at Keele College, England, and also Director of the Nuffield Chemistry Project.

Francis Mechner, Vice-President of Basic Systems, Inc., New York, who is an expert in the design and use of programmed instruction.

Denis Segaller, shell Oil Co., England, who is an expert in the

production of science films and has developed 8 mm film loops for the Nuffield Chemistry Project.

H. J. Arnikar, Professor of Chemistry, University of Poona, India, who has been closely identified with the chemistry institute programme in India and is an expert in physical chemistry.

V.A. Glushenkov, Assistant Professor of Chemistry, Moscow Pedagogical Institute, who has been working as a UNESCO expert in India.

Le Xuan, Programming Expert with the Education Department of UNESCO

Once the Pilot Project has developed suitable teaching materials, it is necessary to try them out with students. Preliminary trials will be conducted by the project with English language students. For further trials in Asian Schools we look to assistance from study groups. Each participating country has been asked to establish one or more study groups affiliated with the Pilot Project. These study groups will be kept in touch with Pilot Project activities and be consulted on a variety of questions. It is hoped that the study groups can provide translation facilities. Most important to further development of improved science courses is the nucleus provided by the study groups. Through them it is hoped that the efforts initiated by the pilot project will be continued. Participants in the Pilot Project expect to return home and act as resource people and sources of inspiration for study groups. UNESCO plans to provide some coordination service and a limited amount of supplies as the study groups continue work over the next several years.

Improved understanding of natural phenomena is a never ending task. With improved understanding come new and better possibilities for science education. The UNESCO Pilot Project is one of several efforts directed towards combining the best insights of modern science with the best teaching procedures. The goal is: young people with a zest for and an ability to pursue inquiry into the world around them whether they become professional scientists or not. Through inquiry, it is believed, will develop increased awareness of the manifold ways in which diverse experiences can be tied together in a meaningful way.

Work Done

The first topic taken up by the participants was stoichiometry. This topic has to do with the mass relation that is characteristic of a chemical reaction. It has seemed wise to divide this topic into two parts. The first part is qualitative in nature and is concerned with the characteristics by which a chemical reaction may be distinguished from other types of change. The second part is more quantitative and is concerned with the measurement of the mass ratio between the components of a reaction.

The general method adopted for the development of a topic is based on a detailed analysis of the subject matter. With the detailed analysis in hand it is then possible to work out a suitable programme of study for the student. In the analysis of the nature of a chemical reaction it is interesting to note how difficult it has been to get agreement among the group of chemistry teachers in the project. It may well be that there

is no generally satisfactory definition of a chemical reaction that can be applied with equal fitness to every situation. However, we are pretty well agreed on the simplest case.

The simplest observable chemical reaction seems to be one in which the mixing of two different initial materials gives rise to a new phase that differs from each of the initial materials. This new phase forms the entire system for just one composition of the system. For all other ratio of the initial materials the final form of the system is made up partly of the new phase and one or the other of the initial materials. In this form a chemical reaction stands in contrast to the case where the mixing of initial materials leads to a single new phase for all compositions of the system. In this latter case the system is described by the term solution.

Experimental work within the project has been directed toward various systems that can be used with students as examples of chemical reaction K. Nakanishi of Japan and Hi Chul Lee of Korea have been working on the reactions of lead and copper with sulphur. They have previously tried magnasium and sulphur and also iron and sulphur but each proved impractically slow for student use. Peng has been working on the reaction of various metals with iodine.

Several persons have been working on the formation of alums. In particular M. N. Nawabi, Afghanistan and C.H. Khoo of Malayasia have worked on the formation of copper ammonium sulphate from copper sulphate and ammonium sulphate while U Tin Pe of Burma has been working on the formation of nickel ammonium sulphate and A M. Ranaweera of Ceylon has been working on chrome alum. A suggestion by Prof. Arnikar of Poona has led to work by U Tin Pe on the interaction of camphor and menthol. U Tin Pe has also been working on the chromate-dichromate equilibrium. Several other reactions have been explored to some extent by participants. It is somewhat surprising that simple examples of reactions are not easily found.

Two short films have been planned and photographed under the direction of Denis Segaller. The first has to do with the factors that determine sensitivity in the measurement of liquid volume. The second has to do with examples of volume changes that occur when materials are mixed together. A third film is being planned. It is expected that these films will fit into some of the early parts of the teaching programme.

Chemistry With 'Fewer Tears and More Joy'

RICHARD GREENOUGH

EIGHTEEN serious looking young teachers, six of them women, sat or stood at laboratory benches tending to test tubes, small beakers, balances, bunsen burners and other chemistry apparatus. Occasionally, they would consult a book at their side, write something on a pad, or quietly pass a remark to a colleague.

Every now and again, one of them would walk over to consult a supervisor in an adjacent office. From outside came sounds of the ceaseless clatter of Bangkok traffic slightly deadened by the louver windows, or the occasional chatter between students on the campus of Chulalongkorn University.

These 18 teachers had come to Thailand from 12 Asian countries where they were teachers of chemistry in universities, senior schools and teacher training colleges, or attached to Ministries of Education. They took part in a recently launched UNESCO pilot project on chemistry teaching in Asia. They represented the following countries: Afghanistan, Burma, Ceylon, the Republic of China, India, Israel, Japan, Korea, Malaysia, Pakistan, Philippines and Thailand. A nineteenth teacher is expected shortly from Nepal.

Behind this project is the growing world emphasis on scientific knowledge and the need for more and wider science education. Purpose of the project is to help countries of Asia through regional cooperation to discover ways most suited to Asia's needs to redesign, simplify and streamline chemistry teaching, chiefly in secondary schools and universities, in accordance with the best and latest contemporary thinking among the world's scientists.

Explaining the Whys and Wherefors

The project is based on new techniques of instruction. It leads the group through all the steps whereby each teacher can personally discover and work out the basic laws of chemistry, the actual why and wherefores of chemical transformations, reactions, formulae, results and so on

A similar pilot project on the teaching of physics in Latin America was recently carried out successfully with UNESCO assistance at Sae Paule, Brazil.

"Student book learning and laboratory work need to be revitalized," I was told by Prof. Laurence Strong, Head of the Department of Chemistry at

Courtesy UNESCO FEATURES

Earlham College at Richmond, Indiana, in the U.S. Prof. Strong, assisted by Prof. Shafqat Siddiqi, Head of the Department of Chemistry at the University of Peshawar, Pakistan, are the two staff directors of the project which is housed in a wing of Bangkok's Chulalongkorn University, by courtesy of the Government of Thailand. Helping them is a staff of seven visiting consultants from India, the United Kingdom, the U.S., the USSR and Vietnam—all professors, lecturers or experts in particular fields of chemistry, whose services are supplied by UNESCO.

"To achieve chemistry teaching with fewer tears and more joy," Prof. Strong went on, "the main efforts of the pilot project are directed towards the development of new laboratory experiments, new materials and new guidelines for teaching chemistry.

"There is a lot of deadwood that has been accumulating over the years in chemistry textbooks and syllabuses that should be cleared away. In the past, too much emphasis was put on learning by rote. What students were taught in chemistry they usually had to accept blindly.

"They almost never got any insight into what was actually happening, of how the end result they were taught about had occurred. They were not told how they themselves could arrive at the various conclusions they had learned by heart, by performing their own experiments."

To illustrate chemical transformations that interest teachers and pupils, Prof. Strong uses a favourite example: "A brown cow eats green grass which makes white milk and gives yellow butter. Then I try to explain what chemical transformations go into producing this," he explained.

The pilot project is much concerned with what parts of chemistry should be taught for the greatest possible advantage and use today, pruning chemistry teaching to the irreducible minimum of content; and deciding how a person should best set about studying the subject and later teaching it.

Two topics that can be useful basic parts of secondary school chemistry teaching have so far been selected for the first year of the pilot project, from *October 1965 to July 1966.* They are: stoichiometry and energy. Stoichiometry in simple language means the examination of a chemical reaction and how it is recognized, with special reference to weight ratio. The study of energy is to decide and determine exactly what energy is and how it is transferred.

Emphasis on Cheapness and Simplicity

The first year of this two-year project will be spent in research and the development of simple inexpensive chemistry teaching materials, including self-contained kits, to serve later as prototypes to be put together locally in each of the participating Asian countries. Also studied is the feasibility of new teaching techniques, inexpensive—often home-made laboratory apparatus, teacher guides, programme instruction, and such aids as 8 mm loop films—which the groups are being taught how to make for themselves.

Emphasis is on cheapness and simplicity, it being realized that school laboratories are scarce throughout Asia, and facilities like gas and electricity are not always readily available.

During the first year, positive steps are being taken to ensure that these prototype materials really do stimulate active follow-up at local and national levels, so that new techniques are channelled effectively to universities, teacher training colleges and schools in those countries taking part in the project.

For this purpose, UNESCO has asked that each of the 12 Asian countries represented in this international group at Bangkok—with Nepal expected as a thirteenth—should organize a national project study group. These groups will operate concurrently with Bangkok during 1965-66. Having served as testing and evaluating centres or what is being learnt at Bangkok, these groups will be asked in 1967-68 to adapt prototype laboratory kits, new materials and methods to local conditions, languages and syllabuses.

Teachers Express their Views

What do some of these 18 teachers think of the project? Mrs. Cleefe Bacungan, Registrar at Philippines Science High School at Caba, La Union, finds the project, "Something very different from the traditional ways of teaching chemistry. It introduces an 'inductive' method of learning. You arrive at ideas and concepts through a laboratory approach. You observe, see and find out things for yourself instead of just learning them out of a book, where often such things are badly described, or even entirely missing."

Dr. Nida Sapianchaiy is one of the four Thai teachers attending the project. A lecturer in chemistry at the College of Prasarn-mit, Bangkok, for the past seven years, with a Ph.D. in organic chemistry from the University of Indiana at Bloomington, she finds the new approach to chemisry teaching "most refreshing and long overdue. However, I think science teaching should be improved at all levels and should be introduced into elementary schools in Asia, with such things as nature study and simple biology."

Miss Ruth Ben Zvi, instructor in the department of biological chemistry at the Hebrew University, Jerusalem, said: "Streamlining of chemistry teaching methods and content will be the first step towards a revision and reshaping of textbooks. This is essential in the present day. I am impatient to put into practice what I am learning here".

A number of others in the group, including Mr. A. M. Ranaweera, Lecturer in Science Curriculum Development at the Education Department, Colombo, Cylon; U Tin Pe, Lecturer in the Science State Teacher Training College at Rangoon, Burma; and Mr. J. P. Trivedi, Professor and Head of the Chemistry Department at St. Xavier's College, Ahmedabad, India, also foresee important changes in the curricula of chemistry teaching as an important result of this project. They feel that present curricula are often too firmly based on existing out-dated textbooks.

To some people, chemistry is something of an occult science bringing inexplicable but marvellous results of great use and value. To a few, it may still mean playing around with different coloured powders and crystals and water, and producing strange odours and a few bangs.

To the group attending this UNESCO pilot project, what they are learning

opens up a whole new encyclopaedia of facts and possibilities. In so doing, they are both helping to modernize chemistry teaching in their own countries and playing their role in the spreading of science education in the world.

A distinguished Asian diplomat recently drew attention to the inventive past of the continent of Asia. It is well-known, he said, that Asians were the first to discover fire, the making of pottery, the smelting of ores, the use of irrigation, the manufacture of paper, gun powder and even rockets, as well as the art of calculation including the invention of numerals, the decimal system and other means of measurement, all among the basic essentials of modern scientific and technological progress.

These 18 teachers, if they cast their minds back a few centuries as they work at their laboratory, could well be forgiven for telling themselves, "This is where we came in . . ."

Also see pp. 177-178.

Young Folks Corner

Rothamsted Experimental Station and Sir John Russel

N.R. DHAR

IN 1832, a young man, John Bennet Lawes (1814-1900) of a well-to-do family, who possessed landed property Rothamsted, HERTS, which is about 25 miles from London, joined the University of Oxford. He did not complete his degree course at Oxford but returned to Rothamsted in 1834 and soon afterwards started experimental work in crop production, first in pots and then in fields with 250 acres of land by using ammonium sulphate obtained from the coal gas industry, sodium nitrate from the deposits in Chile, and animal dung (farmyard manure). He took out a patent for the manufacture of superphosphate by applying sulphuric acid on natural rock phosphates, bones, etc which are practically pure tricalcium phosphates. In this industry he made money and created the famous Rothamsted Experimental Station with a gift of £1,00,000 in 1872 He sold the whole of his fertilizer business for £3,00,000 in the same year. He had other chemical industries at that time which were not sold As he was not properly trained as a scientist, he invited Dr. J. H. Gilbert to join him in these experiments. Dr. Gilbert (1817-1901) was trained by the famous German chemist, Baron Von Liebig (1803-1873), at the famous University of Giessen.

Lawes and Gilbert continued these field trials and laboratory experiments for 57 years and made the experimental station famous all over the world by their investigations. Both of them were knighted by the British Government, Lawes in 1882 and Gilbert in 1893. Sir Henry Gilbert became the President of the chemical section of the British Association in 1880 and President of the Chemical Society, London, in 1882 Their experiments proved that wheat can be grown year after year on the same land without fertilizers, but the yield decreases as recorded in the following table.

Wheat yield in bushels/acre

8 years	(1844-1851)	17.0
20 years	(1852-1871)	13.9
20 years	(1872-1891)	11.1

They applied 43 lbs., 86 lbs. and 129 lbs. of nitrogen and in few fields 200 lbs. of nitrogen as ammonium sulphate or sodium nitrate along with superphosphate and potash and 200 lb. nitrogen as farmyard manure. The average yield of wheat is recorded as follows:

Average in bushels

Farmyard manure ..	35.2
Unmanured ..	12.6
43 lbs. N as ammonium sulphate and minerals ..	23.2
86 lbs. N as ammonium sulphate and minerals .	32.1
129 lbs. N as ammonium sulphate and minerals ..	36.6

(average of 61 years–1852-1912).

The land in which these experiments were carried out was originally fertilized by chalk and when the original experiments were started, it had nearly 5 per cent calcium carbonate, but, in course of time, this lime was washed away by rain and snow and dropped to 3 per cent. One remarkable fact observed in Rothamsted by them was that the soil total nitrogen, which determines land fertility, dropped from 0.122 per cent to 0.095 per cent in the unfertilized field and it was 0.1 per cent to 0.11 per cent in the fields receiving ammonium sulphate or sodium nitrate. But the land receiving farmyard manure and producing steady crop year after year increased in fertility and contained 0.236 per cent total nitrogen in 1893 and the present value is approximately 0.276 per cent total nitrogen.

These experiments clearly demonstrated that artificial fertilizers like ammonium sulphate and sodium nitrate, though they increase the crop yield, do not improve the nitrogen status; but there is a slight deterioration of soil humus, but the organic matter present in farmyard manure largely improves the nitrogen status. These researches have been corroborated in the USA, Denmark, India and other parts of the world proving the value of organic matter in improving fertility permanently.

After the death of Lawes in 1900 and of Gilbert in 1901, Dr A D. Hall (later on Sir A. D. Hall) succeeded as the first Director of this experimental station in 1902 and in 1905 brought out *the book of Rothamsted Experiments* containing results obtained in 50 years. He was the first to prove in Rothamsted that the application of sodium nitrate to land destroys the structure by creating alkali (NaOH) in the soil. He declared in this book that leguminous plants like clover, lucerne sunnhemp, pulses, etc. form the source of soil nitrogen all over the world. This view seems to be incorrect. Dr. E. J. Russell, who started his career as a pure chemist with a D.Sc. degree of London University on the slow oxidation of phosphorus succeeded Hall in 1907 and continued as Director for over 30 years till the second European war. He was succeeded by Dr. W. G. Ogg (later on Sir William Ogg), who continued for over 10 years as the third Director and the present Director is Mr. F. C. Bawden, M.A., F.R.S., an eminent plant pathologist The work of the Rothamsted Experimental Station has greatly expanded and it consists of the departments of physics, chemistry, soil microbiology, pedology, botany, crop physiology, plant pathology, biochemistry, entomology, insecticides, statistics, field experiments and farm staff Library photography and department on the study of bees. The Director receives an annual emolument of £3,000 while the Heads receive £ 2,000. Consequently, the cost has increased enormously and more than 90 per cent of the expenditure is met by the British Government.

During the British regime, from time to time, British experts were invited by the Government of India to report on the improvement of Indian agriculture. The first expert was Dr. J. A. Voelcker, who was in charge of the Woburn Experimental Station created by the Duke of Bedford and the Royal Agricultural Society of England in 1876 for the purpose of carrying on new experiments which could not be performed elsewhere. Dr. Voelcker stayed for nearly a year in India and went over all the government farms and also to some farmers' fields as well as industrial places and studied and analyzed himself the normal and alkaline soils of India, travelling even in the bullock carts, and submitted to the Government of India a famous report on the improvement of Indian agriculture, published in London in 1893 and recorded as below:

"Enormous areas, specially in the plains of northern India, are thus affected, and in the north-west provinces alone, there are between four and five thousand square miles of USAR land." He also concluded that under the existing conditions of agriculture, the soil of India must gradually become poorer.

Sir John Russell was invited by the Council of Agricultural Research in India and he came to India early in January 1937 and delivered lectures at Allahabad, Bangalore and visited Calcutta, Dacca, Delhi and other centres of interest. He declared in his lecture at Bangalore the same statement which appeared in Hall's book that legumes form the source of soil nitrogen.

It is well-known that at the present moment approximately 1,200 million tons of cereals, 750 million tons of other food materials and 1,750 million tons of fodder are produced every year in the whole world. In the *Oxford Economic Atlas of the World* (Oxford University Press 1959) the following results regarding increased yield are recorded:

Increase in yield to 1 kg. of N per hectare

	Wheat	Rice	Potatoes	Grass (or hay)
Kg. per hectare	17	17	84	17

The Indian Council of Agricultural Research has reported that on an average the rice production in India is ten times the amount of nitrogen applied when the dose is not large. Hence, in tropical countries in which the organic matter content is lower than in temperate countries, the beneficial effect of nitrogenous fertilizers is less pronounced. If we take into account the world food and fodder production which is 3,700 million tons and consider the total amount of available nitrogen required for their production, we obtain the figures: 3,700/17—10/2-274.7 million tons.

Actually only 10 million tons of factory nitrogen are available for the world production of food and fodder. Moreover, Dohnis and Fred and other experts in leguminous crops have recorded unequivocally that only five million tons of nitrogen are added to the world soils by growing legumes. Hence, the Rothamsted view that the legumes form the main source of nitrogen is untenable. The researches carried on in the University of Allahabad for nearly 40 years have clearly established that the vast amounts of organic matter photosynthesized by plants on the earth's surface undergo oxidation on the soil surface and fix atmospheric nitrogen on the soil surface more in presence of neutral phosphates and

basic (Thomas) slags and light than in the dark This thermal and photochemical nitrogen fixation, and not legumes or blue green algae, is the basis of soil nitrogen all over the world. The value of farmyard manure depends not only on the nutrients it contains but also on the fixation of nitrogen as proved by Dhar and his co-workers.

Sir John Russell inaugurated the Anniversary Meeting of the National Academy of Sciences, India, held on 15 January 1937 at Allahabad, presided over by Prof. N. R. Dhar, and gave an interesting address. Before his arrival in India he commented in NATURE (11/4/36, p. 629) on the previous presidential address of Prof. N. R. Dhar on molasses nitrogen fixation and land reclamation in the following words :

'Prof. Dhar leads the school of thought which believes that nitrification in soils and nitrogen fixation from the atmosphere are, specially in the tropics, photochemical at least as much as bacterial actions. Prof. Dhar has produced strong evidence in support of his theories . . . The philosophical implications of recognizing that light plays a part in soils analogous to photosynthesis in the vegetable kingdom are at least as important as the practical possibilities of utilizing that knowledge for the enrichment of soil. . . The practical facts of Prof. Dhar's researches are that Indian soils are generally deficient in nitrogen, that more than half a million tons of molasses from the sugar industry are annually wasted in India and that the application of molasses to the soil can double and may treble the soil nitrogen content, with a consequent large increase in crop yield. . . Prof. Dhar suggests that a most valuable use can be made of molasses in reclaiming alkaline land. The acids produced in the decomposition of molasses neutralize the alkalis, and at the same time and contrary to experience when land is reclaimed by gypsum or sulphur, soil nitrogen is increased. A period of about four years is usually necessary to reclaim alkali land with gypsum, whereas with molasses applied at the rate of 30-40 tons per acre, good crops can be grown within six months . . There are four million acres of infertile alkali land in India, and irrigation practices are increasing the area. The economic reclamation of these lands is one of the country's greatest problem in her agriculture, to the solution of which Prof. Dhar's work is pointing the way."

Sir John Russell carried out interesting experiments on the loss of nitrogen from soils in the form of nitrogen gas on the application of nitrogenous manures. As a matter of fact the Rothamsted workers have reported an average recovery of 25 to 30 per cent of added nitrogen in the crop. The majority of the applied nitrogen to soil is lost and is not added to the soil or even taken up by the crop. Similarly, in Sweden, 30 per cent of the nitrogen is recovered in the crop and 70 per cent is lost. From researches carried on at Allahabad by numerous research scholars of Prof. Dhar, it has been clearly proved that all nitrogenous compounds, when applied to land, undergo slow oxidation in air and get converted temporarily into the unstable explosive substance, ammonium nitrate, which is readily decomposed with great evolution of heat as in the

equation: $NH_4NO_2 = N_2 + 2H_2O + 788$ K.cal This loss is more marked in cultivated lands where oxidation processes are quick.

Sir John Russell published numerous books and articles which were written in very clear and lucid manner. His best known publications are: *Soil Conditions and Plant Growth* (Longmans Green & Co. 1912) and the eighth edition revised by his son, Dr. E. Walter Russell in 1950, who is a Professor in Soil Science, Bristol University. Other important books of Russell are: *Fifty Years of Field Experiments at the Woburn Experimental Station* (first published in 1936 Longmans Green & Co.), *Manuring for Higher Crop Production* (Cambridge University Press 1917), *Artificial Fertilizers in Modern Agriculture* (H.M., Stationery Office 1939), *Microorganisms in the Soil* (1923), *Plant Nutrition and Crop Production* (1925), *A Student's Book in Soils and Manures* (1940), *The Farm and The Nation* (1933), *English Farming* (1941), *World Population and World Food Supplies* (1956). *The World of Soils,* in which Sir John Russell recorded his considered opinion that the improvement in food production in the UK in recent years has been at a tremendous cost In his book *World Food and World Population* he clearly stated that the increase of population in India by 40 millions in 10 years is an extremely difficult affair and may lead to impossibility in feeding the increasing population. Moreover, he strongly held the view that international control of world food supply is not a practical proposition.

Researches carried on at Allahabad have proved that all organic matter including dung, sawdust, grasses, peat, lignite and waste coal when ploughed in with basic (Thomas) slag, which is the by-product of the expanding steel industry, but not utilized in India, can fix atmospheric nitrogen copiously and can supply all the plant nutrients not only to the normal land but can also reclaim alkaline land permanently. Dhar and his co-workers have emphasized that the residual effect of phosphates on crop is much better by the addition of neutral phosphates of basic (Thomas) slag than super-phosphate which has been supported by K. Simpson (Scot. Agric. 1963, 43, pp. 81-85). Hence, it is high time that India should utilize its basic slag for crop production.

I had the privilege of meeting Sir John Russell first in 1917 in the Chemical Society of London, which I joined in 1916. In his address to the Chemical Society in 1917 Russell discussed the feeding of the British people during the first world war. He attended the Indian Science Congress Session in 1952 at Bangalore. I had the honour of delivering lectures in the Rothamsted Experimental Station at his invitation in 1937, 1951 and 1954 during the Directorship of Sir William Ogg and in 1961 in the regime of Mr. F. C. Bawden.

Sir John Russell was born in 1873 and was a clergyman's son. One of his sons is a Catholic priest. He was exceedingly happy to meet Acharya P. C. Ray in 1937 at Calcutta, because both of them were great believers in plain living and high thinking.

He was President of the British Association as well as of the International Soil Science Congress held at Oxford and was invited to visit the agricultural

projects in the USA and the USSR where he delivered lectures. He was invited by numerous countries of Europe — Australia, New Zealand and Canada.

He was honorary fellow of the Royal Institute of Chemistry London, National Institute of Science of India, Foreign Member of the French Academy of Agriculture and Foreign Associate of the French Academy of Sciences.

Sir John Russell acted as a foreign examiner for the Ph D. or Phil. or D Sc. degree theses of the Allahabad and other Indian universities.

In his book *World Population and World Food Supplies* 1956, Russell has stated. "There is at present time much anxiety about food supplies for the world in general and for Britain in particular." In the same book he also stated: "One Hindu who was in a temple in which I was not allowed, stated, 'Give me money and I will eat for you in the name of God' "

Russell has stated that the pre-war expenditure on the United Kingdom Department of Agriculture was 8 9 million pounds and in 1950 it went up to 64 million pounds and the caloric production rose from 30 per cent of the requirement to 41 per cent.

Science Notes

Ultra-high vacuum

GASES which form chemical compounds with titanium can be pump-down to very low pressures at high speeds with a new sublimation pump, believed to be the first of its type made by a British company, produced by Vacuum Generators of Charlwoods Roads, East Grinstead, Sussex.

For fresh titanium, obtained by evaporation from a filament on to any convenient wall surface within the vacuum system, pumping speeds of 20 litres per second square inch have been recorded for hydrogen at room temperatures rising to 90 litres at liquid nitrogen temperatures.

The pump comprises a filament array with a low tension supply and the filaments are a special alloy of titanium and molybdenum.

Plastic and films in colour X-ray

Black and white X-ray plates are often extremely hard to interpret because of the poor contrast between different parts of the image British scientists working on the European Dragon Nuclear Reactor Project in Britain have now come up with X-rays in colour and also moving film. This could cause a revolution in testing and inspection in the engineering field, and provide a useful tool in medicine.

The first time colour film was used for X-ray photographs was probably in the USA about 20 years ago If one puts colour film behind the object to be X-rayed the differing exposures to X-ray in the object's shadow give different shades of colour, just as a badly exposed holiday colour snap can reproduce shadow colours quite wrongly. This colour difference is supplementary to the changes of density of the image and helps to make minor details much clearer than they are in a black and white X-ray photograph Also, if you deliberately 'fog' the film—expose it to coloured light during development—this can further increase the colour contrast.

Despite the obvious advantages of this technique it did not become very popular and the results were unpredictable. Then the dragon project had a particularly different problem, checking for minute defects in the fuel elements for their high temperature reactor. With black and white X-rays some faults hardly showed. So the colour process was improved into a consistent and reliable

test procedure and now even to a untrained eye, tiny details, hardly visible in ordinary X-ray photographs, can be seen clearly in the colour versions.

The work *has recently gone very* much further, and patents have been applied for. The colour technique has been adapted to producing sharp, contrastry-multi-colour pictures from the fluoroscope—the dim green screen used for visual X-ray examinations. Even super slow-motion colour X-ray cine film has been made They have photographed the insides of high-speed machinery in operation. A failure that develops in one second inside an electric motor or pump can be slowed down to four minutes of clear colour on the screen. With a clear understanding of what goes wrong, it is easier to remedy the fault.

In medicine this could be a tremendously powerful tool. Before some kinds of heart operation, for instance, fluoroscope examination of the working heart is needed. Surgeons have to be very skilled at interpreting pictures they see on the fluoroscope-blurred and too dim for more than one or two to see. Often closed-circuit television is used to show the picture to a group of experts for discussion of the case. Now coloured, slow-motion cine films can be taken by X-rays, the pictures could be re-run until the panel of surgeons was sure of its conclusions. The technique is at the stage where the medical world can experiment with it.

A fibre with twice strength of steel

A new material, claimed to be twice as strong as steel but only a quarter of its weight has been developed at the Royal Aircraft Establishment at Farnborough. It was featured in an exhibition seen by the queen at Farnborough.

The process is based on 'a polymeric *fibre akin to textile*' which is converted by means of chemical change to carbon fibres. This can be turned into usable plastic by coating it with hot or cold setting plastic material.

The resulting product is said to be twice as strong and twice as stiff as steel (stiffness in this context means resistance to deformation under pressure), it is also six times stiffer and slightly stronger than glass fibre.

Extensive uses for the new material are foreseen in the aeronautical field, where its light weight will outweigh the disadvantages of higher costs, and it is expected that marine and chemical engineers will also be quick to take it up.

At present, the new product is officially described as 'carbon fibre reinforcement of structural plastics'. It may well come to be known as carbon-fibre plastic, on the analogy of glass-fibre plastic.

Plastic microbes

More and more things are being made of plastics these days because of their cheapness and durability. But because plastic items are so durable, they present mankind with a refuse disposal problem. At the National Physical Laboratory, some work on quite a different problem—the problem of protecting plastics from attacks by bacteria—has suggested a possible way of getting rid of plastic garbage.

The first obstacle to be overcome is the fact that the bugs only go for the flexible forms of plastic, they cannot

digest the long chains of molecules which make up the rest of the material. But there are some bacteria which go for the long molecule chains in petrol and in jet fuel. The idea was to introduce a petrol-eating bug to some plastic which resembles petrol in some of its molecular characteristics. A new strain should develop and then you'd continue the process until you produce a range of bacteria capable of disposing of all the plastic we throw away.

There is another possible method too. To bombard plastic waster with X-ray or gama rays to break down its long molecule chains, so that it becomes edible by bacteria. In Sweden, they think you might be able to build a delayed-action organism into plastic bacon wrappers for example, so that after a week or so the wrapper just disappears.

By Courtesy : SCIENCE NEWSLETTER
Indian High Commission, London

What we learn from animals

The following are extracts from presidential address of Prof Pringle to Zoology Section of this year's meeting of the British Association for the Advancement of Science, which is being held in Nottingham.

Prof. Pringle's address, delivered on 1 September was entitled 'The Treasure House of Nature'.

Zoology as a scientific discipline attempts to introduce some sort of classification and order into the enormous and obvious diversity of the forms of animal life on earth. It rapidly progressed to the attempt to classify not only the external and internal shapes of animals but also the associations in which they lived, the behaviour of animals and finally the inner mechanisms of their functioning.

It is this last activity—the study of the working of animals as biological machines—that has developed into the subject of comparative physiology.

The Zoologist's Contribution

Where would we be in the science of genetics if Morgan had not recognized the peculiar advantages of an unimportant little fruit-fly *Drosophila*? How far would Professor Hodgkin have got with elucidating the basic ionic mechanism of nervous conduction if a zoologist, J. Z. Young, had not spotted the giant fibre of the squid?

My research group in Oxford is working almost exclusively on the flight muscles of giant water bugs. Not only does the type of insect striated muscle on which we are working make it possible to get information about elementary molecular processes which could not be obtained from any other type of muscle, but this particular family of insects has features which make these muscles much better than those of other insects.

It has taken me 25 years to find this particular muscle, but I have little doubt that before long giant water bugs will be in demand by biophysics laboratories all over the world

Mankind is in trouble. Applied science, particularly physical and medical science, has upset the natural balance of the world and pure science has so far failed to find the remedies.

Problem of Over-population

Physiology, in its applied form as medical science, has indeed given great benefits to mankind. But one of the difficulties to which it has given rise is the great increase in human numbers. It is only recently that it has been recognized that the study of animal populations has a direct bearing on the problems of demography and that biology can help mankind to find the answer to this urgent problem.

Very little support and encouragement is given to the study of animal population, largely because zoologists have not tried hard enough to persuade others that we really can help to solve this practical human problem.

Over-population is only one of our present problems to which the comparative approach of the zoologists has a lot to contribute. At the root of most human difficulties is the character and behaviour of man himself.

Here again it is just beginning to be realized that there is a lot to be learnt from animals We might all behave in a more balanced way if we understood the origin of our emotions.

It will not be easy to introduce into general education sufficient knowledge of the nature of human and animal behaviour to overcome emotional and social difficulties. We have to do it carefully because zoology has done itself harm in the past by the too easy assumption that man and the higher animals are alike in the evolution of their social organization. But we can point out the nature of the differences.

Importance of Conservation

We should not destroy the potential contained in the animal kingdom for the future advancement of knowledge We do not know where in biology any given line of enquiry is going to lead us, or what hitherto unthought of problem may require a particular species of animal for its solution. But we cannot afford to destroy any opportunity, for once gone it can never be restored.

The ferret still survives. The susceptibility of the ferret to the virus of human influenza was, at one time, an important factor in progress towards the control of this disease.

No one can say that there may not have been some peculiar feature of the great auk which would have enabled us by now to have found the answer to some other human medical problem. I know this will sound far-fetched, but it is a valid statement.

By Courtesy · British Information Services, New Delhi

Mathematical Problems

J. N. Kapur
and R. C. Sharma

Solutions of problems SS1 to SS15 (published in March 1967 issue of School Science*) should reach Shri R. C. Sharma, NIE Buildings, Mehrauli Road, New Delhi by 15 August 1967 and those of SS16 to SS19 published in this issue should reach him by 30 September 1967. Each problem should be solved on a separate sheet of paper and should bear the name of the student, his class and his school and should carry a declaration that he has solved the problem himself. Persons other than students can submit solutions, but they will not be eligible for any prizes that may be awarded at the end of the year.*

Correct solutions of SS1 to SS10 together with the names of those who solve them correctly will be announced in September 1967 issue of School Science. *Similar announcement for SS11 to SS19 will be made in the December 1967 issue of* School Science.

Original problems (together with solutions) for September and December 1967 issues are invited.

SS16 Show that the number

$$a_0\, a_1\, a_2 \text{ —— } a_n$$

(Where aI's are digits) is divisible by a prime number p(2 or 5) if $a_0\, 10^{n-1} + a_1\, 10^{n-2} + \text{——} + a_{n-1} - k a_n$ is divisible by p where k is an integer such that $10\,k+1$ is divisible by p. Use this result to find whether 390224 is divisible by 29.

SS17 You are given two sets of numbers :

$$N = \left\{ 1, 2, 3, 4, 5, 6, 7, 8, 9, \ldots \right\}$$

$$E = \left\{ 1, 2, 4, 6, 8, 10, 12, \ldots \right\}$$

and the following definitions:

(i) A member x of a set s is a factor of y if there exists a member z of s such that $xz = y$

(ii) A number is a prime number if and only if its only factors are unity and the number itself; other numbers are called composite.

For these sets, prove the following statements:

(i) The number of primes in

N is infinite

(ii) There exists a formula for all primes in E

(iii) Every composite number cannot be factorized uniquely into a product of primes.

Answer these questions also for the set

$$T=\{1, 3, 6, 9, 12, 15, \ldots\}$$

SS18 Assume that a club of students is organized into committee in such a way that each of the following statements is true:

(i) there are at least two students in the club

(ii) every committee is a collection of one or two students

(iii) for each pair of students, there is exactly one committee in which they serve

(iv) no single committee is composed of all the students in the club

(v) given any committee and any student not on that committee, there exists exactly one committee in which the student serves which has no student of the first committee as its member.

Prove each of the following statements in the following sequence, justifying each step of your proof by appealing to one or more of the five postulates or to an earlier statement of the sequence:

(i) every student serves at least on two committees

(ii) every committee has at least two members

(iii) there are at least four students in the club

(iv) there are at least six committees in the club

SS19 Let

$$\begin{aligned}K = {} & (x_1-x_2)^2+(x_1-x_3)^2+\ldots+(x_1-x_{2m})^2\\ & +(x_2-x_3)^2+\ldots+(x_2-x_{2m})^2\\ & +(x_3-x_4)^2+\ldots+(x_3-x_{2m})^2\\ & +\ldots+(x_{2m-1}-x_{2m})^2\\ = {} & \sum_{\substack{i,j=1\\ i<j}}^{2m}(x_i-x_j)^2\end{aligned}$$

Find the maximum value of K if it is known that each x_i $(i=1, 2, \ldots, 2m)$ has the value 0 or 1.

New Trends in Science Education

Summer School in Biology 1966 —A Participant's Reaction

AMIT BANERJEE

AS a part of the following-up training programme under the Science Talent Search Scheme, the Department of Science Education organizes several summer schools in basic sciences for the awardees of the Science Talent Search Scholarships.

The main objective of such summer schools is (i) to convey to the talented young scientists, the various advances made in and (ii) to enable the young scientists to understand these advances through laboratory experiments lectures, symposia, seminars and filmshows.

As one of the 30 participants who attened the Summer School in Biology held in Delhi from 10 May 1966 to 6 June 1966 I should like to relate some of my impressions of the school.

The Summer School was held at Hansraj College, Delhi for students from Delhi, Punjab, Himachal Pradesh, Rajasthan and Uttar Pradesh. Dr S. L. Tandon, Reader in Botany, Delhi University, was the Director and Dr. V. P. Singh and Dr. H S. Vishoni of the Delhi University and Dr. R D. Gulati and Dr. Y. P. Oberoi, Hansraj College were the other members who acted as resource persons.

The regular academic work consisted of a lecture, discussions and questions on the same, a seminar, and practical work in botany, zoology, as well as in biology. On fridays, filmshows were screened on various modern topics and on saturdays we used to have day-long excursions.

Some of the lectures were on origin of life, evaluation, genetics, reproduction of viruses, hormones and osmoregulation, etc., by Prof. Bhargave, an eminent virologist of India.

Distribution of the synopsis of the lectures beforehand enabled the participants to ask relevant questions.

The lectures were all delivered with the aid of slides, plates, models and charts

The seminars were held in two batches. These brought out the economic importance of plants, animals, micro-organisms, antibiotics, vitamins, etc. Interesting subjects, such as biological control, animal diversity, animal adaptations, etc, were also discussed. These seminars served:

(i) to reveal the degree of individual comprehension and understanding on a subject, (ii) to promote exchange of individual knowledge and viewpoints

and (iii) to tide over one's speech shyness.

The laboratory work involved extraction and separation of pigments, effects of chemicals on the rate of heartbeat, and other similar exercises. Because of the short duties of the school, it was not possible for any participant to take up any project work.

The summer school was a great success despite the differing reactions of the participants.

A few suggestions shared by all the participants are:

1. The duration of the summer school should be extended by at least two more weeks, *i.e.*, it should be for at least six weeks, in order to enable the participants to reach the climax of activities.
2. The place of board and lodging should not be far away from the venue of the summer school.
3. Venues of summer schools, if possible, should also be fixed at places outside Delhi.
4. Proper books of both Indian and foreign authors should be provided. The nearest public libraries, should be requested to provide temporary borrowing facilities to the participants.
5. Some books preferably publications of the NCERT should be awarded to the participants as a token of encouragement.
6. A certificate should be granted to the participants on completion of the summer school.
7. The experts in the Department of Science Education should visit the summer school and encourage the participants.

•

Summer School in Biology 1966 —A Brief Report

S. L. TANDON

A four-week Summer School in Biology for the Science Talent Search Awardees (NCERT) was inaugurated at Hans Raj College on 10 May 1966. In all, 25 participants including 16 girls and nine boys attended the school.

Classification of participants according to class and subject	*Number of participants*
B.Sc. Hons zoology	4
B.Sc Hons. botany	4
B.Sc. general	6
B.Sc. mico-biology	1
Intermediate and pre-medical	10

Lectures

A total of 18 lectures were delivered and these had a wide coverage of biological subjects. The lectures largely excluded the routine class topics. The discussion at the each lecture was in particular found to be very stimulating.

Laboratory Work

Eight exercises each in botany and zoology were held during the entire duration of the summer school. Each of them was a new exercise to the participants, usually not done in their regular classes. They were so designed as to exploit the enquiring attitude of the scientific mind. A discussion was arranged after each exercise, in which the students were found to be particularly interested.

Seminar-cum-Library

The participants were divided into two equal groups for seminars. The topics chosen for seminars were mostly of a general nature. It was particularly noted that the seminar presentation by the students was very much below expectation. In fact, the seminar amounted to another lecture by the teacher concerned.

Library

The students drew books from three sources—Hans Raj College Library, NCERT and Delhi University. Very few students made use of the Delhi University Library which they could visit only in the afternoons.

Visit to Biology Department

The participants of the school were once taken to the Delhi University botany laboratories and once to the zoology laboratories. A variety of experiments in progress were shown and explained. The physiology and tissue culture laboratories of botany department, and those concerning insect physiology of reproduction and induced spawning in fishes in the zoology department were found to be particularly instructive.

Excursions

(i) Visit to Delhi Zoological Gardens for the study of Indian and exotic animals;

(ii) visits to Indian Agricultural Research Institute for seeing the divisions of botany and entomology, the Gamma Garden, and to the Delhi Milk Scheme for gaining a practical experience in the process of pasteurization;

(iii) visit to Okhla and Mehrauli area for studying the acquatic and scrub vegetation; visits to the National Museum and Nehru Museum (Teen Murti) was added in the third excursion.

Film Shows

Three film shows were arranged through the courtesy of USIS, New Delhi, in which a total of 12 scientific and three documentary films were exhibited.

Social

All the participants were found to be well mannered and highly cooperative in all the activities of the school. A short cultural programme was arranged by the participants on the last day.

A Gloomy Day

The school received with great shock the news of the death of Professor P. Maheshwari, Head of the Botany Department, University of Delhi. The staff and the participants collected in the morning of 19 May 1966 to mourn the death of this great biologist, and passed a condolence resolution. The work of the school was suspended for the rest of that day.

Physical Science Study Committee A Review of Work

THE pace of recent advances in physics has been most amazing. Consequently, new developments in industry and technology are constantly making new and heavy demands on society. It has become absolutely essential to reorient our physics teaching, to reconsider its aims and objectives, to alter the method of approach, reorganize the course-content and to develop new teaching and evaluation procedures in keeping with these demands at all levels and specially at the secondary school level.

The Attempt

One such successful attempt is the PSSC attempt.

A physics course has recently been developed by the Physical Science Study Committee in the United States of America. The Summer Institute Programme is being organized at several centres in India jointly by the University Grants Commission, New Delhi; National Council of Educational Research and Training, New Delhi; and United States Agency for International Development, for the last four summers now.

The Approach

The basic idea underlying the PSSC attempt is to recognize physics as one continuous and growing philosophy of nature in action and hence to have an integrated approach for the subject as one unified pattern rather than to study it in discrete sections or sub-topics which apparently look unconnected, e.g., light, sound, electricity, heat, etc.

The Material

The teaching material developed by the PSSC consists of the following:

1. The PSSC Physics (textbook).
2. The PSSC Laboratory Guide.
3. The Teacher's Resource Book and Guide Vols. I to IV.
4. The PSSC Films on Allied Topics in Text—about 100 in number.
5. The PSSC Series of Objective Tests Nos. 1 to 10.

All the above books are now available in India as they have been reprinted by the NCERT at low cost. The films are also available with USIS, NCERT and the UGC New Delhi.

1. THE TEXTBOOK: The PSSC Physics forms the core about which the complete course is built and is one of the most novel works resulting out of the experiences of hundreds of experts in the field of secondary and university education and thousands of secondary school students in the USA. The book takes a very long stride beginning from the fundamentals in each chapter and carries the student to the most modern developments in the topic through a most interesting, exciting and much less mathematical treatment so as to be within the comprehension level of the secondary school students. The book adopts the MKS system of units and supplements each chapter by a 'Home, Desk, Lab.' section consisting of

simple experiments, numerical, graphical and other problems illustrating the underlying facts, principles and concepts in the chapter with respect to situations in real life.

2. THE LABORATORY GUIDE: The laboratory guide of the PSSC is basically and essentially different from its counterparts which lay more stress on relevant theory and become spoon-feeders due to a number of built-in diagrams, observation tables, ready-made precautions, etc. They reduce the laboratory experiments to a mere mechanical series of observations and calculations for the student. The PSSC laboratory guide serves as an intelligent companion for the student giving him only the most essential technical and mechanical framework of an experiment but leaving most of the physics to him. Several questions are raised in the experiments giving scope to intelligent thinking and logical reasoning by the student, developing his scientific attitude and giving him the joy of discovering things for himself. It also develops his skill in laboratary techniques and his resourcefulness. The experiments are designed on the basic principles and facts rather than on their applications.

3. THE TEACHER'S RESOURCE BOOK AND GUIDE: The teacher's resource book and guide in four volumes, one for each section of the textbook, is a most valuable teaching aid for the teacher and guides him in details about the method of presentation of a particular topic, chapter by chapter. It also excites his initiative and resourcefulness by suggesting new ways of presentation and new experiments to heighten the overall effect of teaching. It also gives solutions to the problems in the 'Home Desk and Lab.' section of the textbook and answers to the questions raised in the laboratory manual. Thus it is most helpful for all teachers and specially for teachers in the remote parts of the country where facilities for library and equipments in the laboratory may be very unsatisfactory.

4. THE FILMS: There are about 100 films based on topics of the PSSC textbook and some of them are in colour. They are doubtlessly a very important audio-visual device for motivation and elucidation of physical principles, facts and concepts. When it is not possible to provide direct experience to the student in the laboratory, the films come to the rescue of teacher in extending his laboratory experience by showing experiments beyond his reach.

5. THE TESTS: The complete textbook of the PSSC Physics is covered by a series of 10 objective multiple choice tests, each of 45 minutes' duration. Each test contains 35 questions with five probable answers to each question very intelligently designed to measure the attainments and grasp of the student on the fundamentals of the topics. The method eliminates rote memorization and cramming on the part of the student and forces him to study the text in detail. The tests are such that no help-book or guide can help the student.

The Teaching Technique

The PSSC method of teaching is textbook-centred and consists in motivation and elucidation of the textbook topic by means of demonstrated lectures and films. These are supplemented

by first-hand laboratory experience of the topic by means of simple and direct experiments with the help of standard kits. Theory and experimentation go hand in hand usually one pointing to the other. Most of the apparatus is extremely simple in design and can easily be improvized by any intelligent, resourceful and zealous teacher or student with some initiative. This is further reinforced by class discussions and group discussions and solving of numerical, graphical and geometrical problems from the 'Home, Desk and Lab.' section of the textbook. Thus all round effort is made to bring home the underlying facts, principles and concepts by individual attention to each student as far as possible.

Adaptability of PSSC Material

A critical examination of the PSSC material with regard to its adaptability in Indian secondary schools was undertaken by me with special reference to the syllabi of the high and higher secondary examinations of the Madhya Pradesh Board of Secondary Education in 1968. It is presumed that the syllabi for these standards in other states of the country would be more or less at par with those in Madhya Pradesh.

It was found that the PSSC course could not be adopted as it is under the present limitations. One of the major hurdles was found to be the medium of instructions which is the regional language of the state and not English. Regarding the course-content it was found that most of it could be incorporated without much difficulty in some way or the other, as detailed in the Appendices I and 2. Actually it is not the content of the PSSC Physics which is important, but the integrated approach and the spirit of the PSSC Physics. The subject as one unit is far more important and needs to be followed in our schools.

It was felt earnestly that some of the more essential and fundamental advances in modern physics should be included in the secondary school curriculum. They are given in Appendix 3. In order to cope up with this increase in content, some topics in properties of matter and heat, *e.g.*, density determinations, thermometry, calorimetry and specific heat, etc., should be shifted to class VIII of the middle school stage.

In order to make a full use of the films, they should be dubbed in regional languages, and the help of such agencies like the extension services departments running under the Department of Field Services should be taken for the display of films in each big school or group of small schools. The other materials of the PSSC should also be translated as early as possible into the regional languages.

Conclusion

In the end, I wish to emphasize once again that inventions and discoveries in physics will continue to pour at their own fast rate. It is for us to rise to the occasion and keep pace with them.

APPENDIX 1

Adaptability of the PSSC Textbook (Under present conditions)

CLASS IX		CLASS X		CLASS XI	
Topics as per syllabus	Material from PSSC Physics	Topics as per syllabus	Material from PSSC Physics	Topics as per syllabus	Material from PSSC Physics
Rectilinear propagation of light, formation of shadows. pin-hole camera, reflection and refraction of light and their laws, images by plane mirror, lateral inversion, image by two inclined mirrors.	Chapters 11, 12, 13	Velocity, acceleration, equations of motion, force, momentum, Newton's laws of motion, moments	Chapters 20, 23, 24	Newton's laws of motion, work, energy power	Chapter 20
		μ of glass, other effects of refraction, spherical mirrors, lenses, use of lens, formulae, camera, eye, optical lantern, simple microscope.	Chapter 14	Laws of gravitation, gravity, centre of gravity, acceleration due to gravity, value of 'g' simple harmonic motion, centripetal force, centrifugal force, earth satellites.	Chapters 22, 24, 25
Fundamental units, C.G.S., F P S. and M.K.S. Units, Vernier callipers, screw gauge, spherometer	Chapters 1, 2, 3	Oersted's expt Magnetic field due to a current, field due to straight current, field at the centre of a circular coil, electromagnetic units.	Chapters 29, 30	Electromagnetic induction, Discharge of electricity through a gas Photo-electric cell.	Chapters 29, 31
		Outline of atomic structure, cathode rays, X-rays α, β, γ-radio activity.	Chapter 33		

APPENDIX 2

Adaptability of PSSC Laboratory Guide (under present limitations)

CLASS IX		CLASS X		CLASS XI	
Experiment already as per syllabus	Experiments that could be taken in science club activities	Experiments already as per syllabus	Experiments for class demonstration	Experiments already as per syllabus	Experiments for class Demonstration
II.1 Reflection from plane mirrors	I.1 Short time intervals I.2 Large distances I.3 Small distances I 5 Speed and acceleration I.6 Small masses	II 2 Images by concave mirror II 3 Refraction II.4 Images by convex lens	II 5 Refraction III 2 Changes in velocity with constant force III 3 Dependence of acceleration on force and mass III 8 Momentum changes in an explosion III.10 Collision in two dimensions III 11 Slow collisions IV.1 Electrified objects IV 2 Electrostatic induction III 6 Centripetal force III 7 Law of equal areas	II 6 Intensity of illumination as function of distance III 1 Variation of Galilio experiments III 2 Energy of simple pendulum	I 7 Spectra of elements IV 7 Magnetic field of a current IV 8 Magnetic field of a straight current IV 5 Potential difference IV 3 Force between two charged spheres

APPENDIX 3

(*a*) *List of topics which should be included in the Higher Secondary Syllabus at an early date.*

1. Heat, molecular motion and conservation of energy.
2. Exploring the atom.
3 Photons and matter waves
4 Quantum system and structure of atom
5 Introduction to waves
6 Interference of a light diffraction
7. Light waves

(*b*) *List of experiments which should be included in the Higher Secondary Syllabus for demonstration by the teacher in class XI PSSC Lab Manual*).

II 13 Interference and phase.
II.14 Young's Experiment
II.15 Diffraction by single slit
IV 9 Measurement of magnetics field in absolute units
IV 10 Mass of an electron

News and Notes

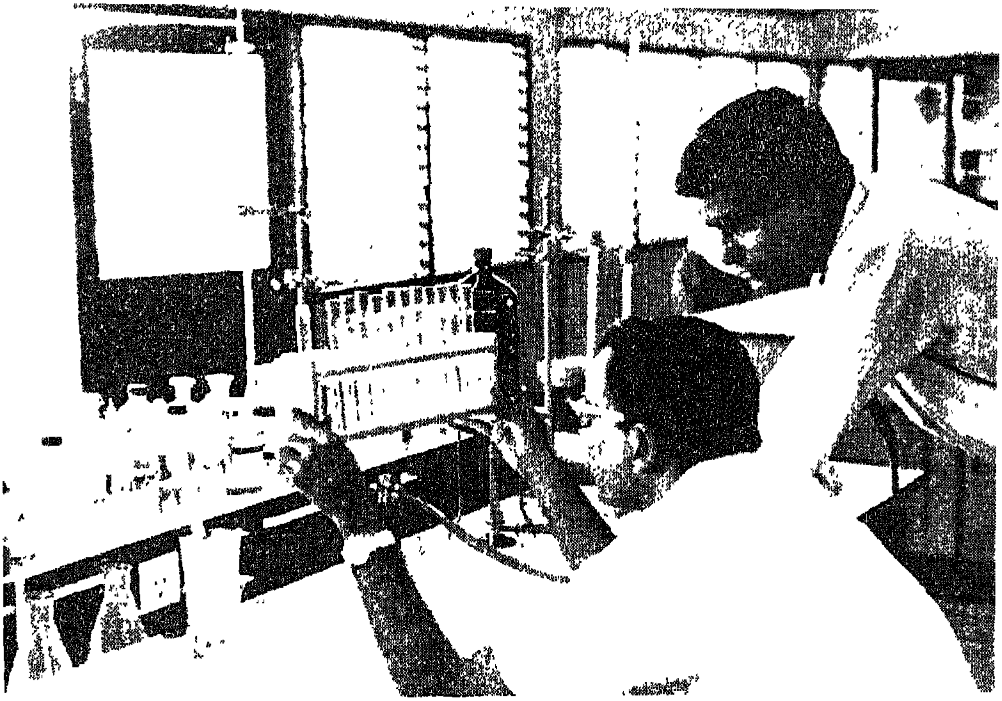
Trainees in Summer Course

SCIENCE TALENT SEARCH SCHEME SUMMER SCHOOLS

With the decision to extend the project to 30 more schools during 1966-67, it was decided to organize a one-month summer course of intensive in-service training for teachers. With the cooperation of the Directorate of Education in Delhi, some 58 teachers were selected for the above course. Two laboratory work-rooms were set up with necessary equipment and furnitrue. Teachers of the physics-mathematics group worked in one room and those of the biology-chemistry group in the other. These rooms were furnished with demonstration tables and work tables that were designed and made in the Central Science Workshop.

The course started on 10 May 1966 with 58 participants from 30 selected schools of Delhi. For the first few days the UNESCO experts addressed these teachers on topics of pedagogy. Later on, the participants were divided into two groups for detailed discussion of the subject contents: (a) mathematics-physics and (b) biology-chemistry. Every participant was thus trained for two subjects. Nearly 46 hours were spent in each subject for discussion and experimentation. The analysis of the syllabus and the teaching themes were discussed during these periods. In all these discussions, the emphasis was on the experimental approach towards the teaching of subject. The participants did all the individual as well as demonstration experiments. They took a keen interest in the laboratory work and the discussion on the analysis of the themes. They were of the opinion that the new course is highly interesting and the students would show enthusiasm for the experimental work in teaching.

In each subject, about ten lectures were arranged on advanced topics.



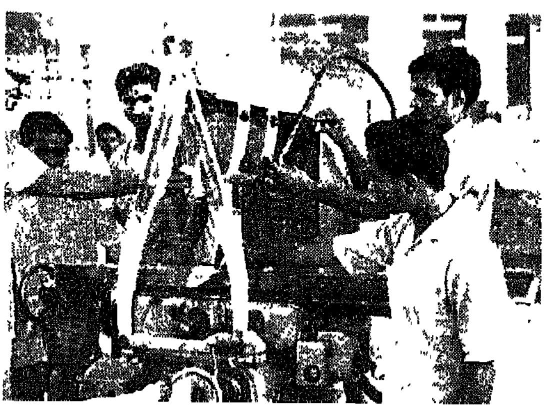
Dr Trivedi of Ahmedabad is conducting an experiment as an interested trainee looks on.

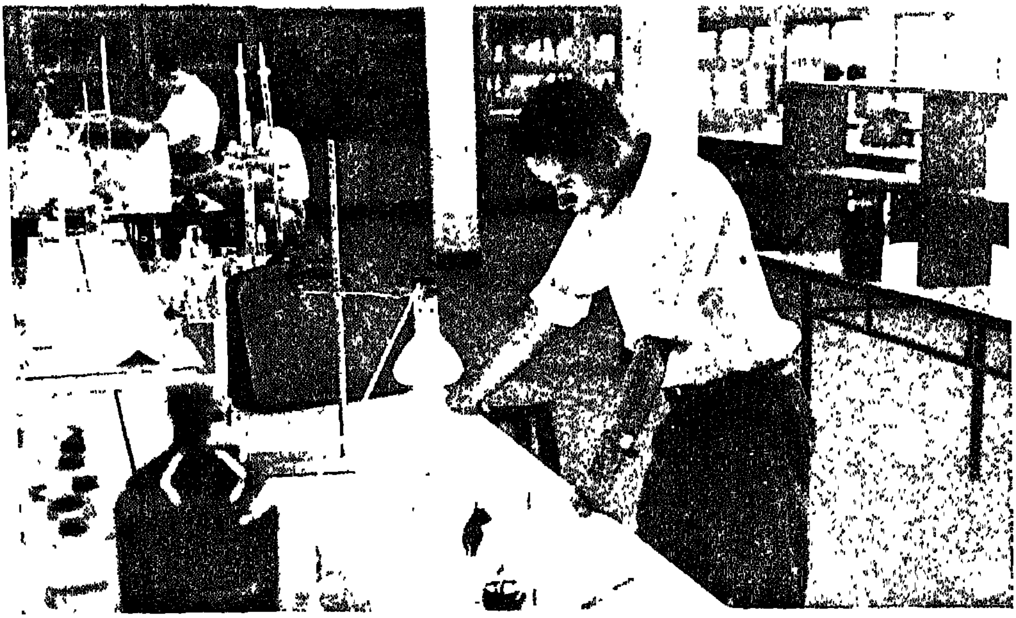
Some of these lectures were delivered by the members of the department, while others were delivered by the members of the faculties of Delhi University.

SCIENCE STUDY GROUPS

A conference of scientists and educators was held in Delhi from 21 to 23 April 1966 to discuss the question of improving science education in schools and to think of ways and means of drawing up plans for the same. It was strongly felt that the curriculum in science had to be revised and analyzed, and books with the guide materials prepared as early as possible. In order to implement these decisions, the conveners of the four subject groups—physics, chemistry, Biology and mathematics—met in the Department of Science Education on 28 and 29 June to work out the details of the programme. Twenty-one study groups—five each in physics, chemistry and biology and six in mathematics—have been set up each under the leadership of a reputed university professor

Practical Demonstration.





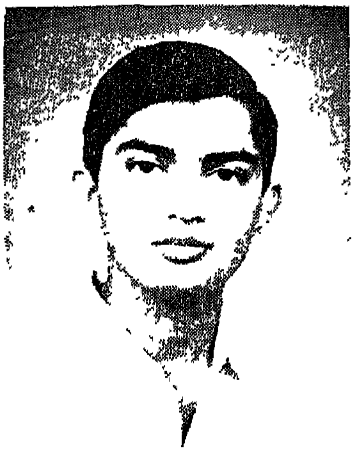
Mr Ranaweera of Ceylon at UNESCO Pilot Project.

It is hoped that the study groups would complete their work by the end of December 1968.

Trainees at Work in the Summer School.

SCIENCE TALENT SEARCH SCHEME SUMMER SCHOOL

Sixteen summer schools were held during May 1966 for the awardees of the Science Talent Search Scheme Six centres were selected for the purpose, namely· Delhi (4), Allahabad (2), Patna (2), Bangalore (3), Calcutta (2) and Bombay (3). This year these summer schools were organized according to subjects, the distribution being physics-5, chemistry-4, biology-4 and mathematics-3. The idea of holding summer schools for each subject separately aroused great enthusiasm among the participants. Interesting prog-



H P Trivedi

Chhanda Chattopadhyae

rammes of activities like special lectures, projects, laboratory work, film shows and seminars were arranged in each school. The total number of participants was 500.

Locations of Summer Schools to be held from 15 May to 14 June 1967, have been listed in the table on next page The names of directors have also been mentioned there.

A View of the Practicals at the Science Talent Search Scheme of the Summer Schools.

SUMMER SCHOOLS FOR 1967—A LIST

PHYSICS

Prof H Narasimhaiah
Principal
National College
Bangalore

Dr. S.C. Jain
Head of Physics Deptt
Indian Institute of Technology
New Delhi

Prof R.D. Godbole
Principal
Ram Narain Ruia College
Bombay

Prof. B M. Anand
Punjab University
Chandigarh

Prof. J. Verma,
Maharana Bhupal College
Udaipur

Prof. B D. Nagchaudhari
Saha Institute of Nuclear Physics
Calcutta

CHEMISTRY

Dr. K. Srinivasan
Principal
College of Arts and Science
K.R. Road, Viswaswapuram
Bangalore-4

Prof V K. Phansalkar
Poona University
Poona

Prof R P Mitra
Delhi University
Delhi

BIOLOGY

Prof. R D. Misra
Deptt. of Botany
Banaras Hindu University
Banaras

Prof. T.V. Desikarchary
Madras University
Madras

Prof B R. Seshachar
Delhi University
Delhi

MATHEMATICS

Prof. J.N. Kapur,
Indian Institute of Technology
Kanpur

Prof R S. Verma
Delhi University
Delhi

Prof. P.L. Bhatnagar
Institute of Science,
Deptt. of Applied Mathematics
Bangalore

Note: The Schools will run from 15 May to 14 June 1967.

Books for your Science Library

Chemistry: Published for the NUFFIELD FOUNDATION. Longmans/Penguin books 1966.

Interest in the development of science education in the secondary schools and dissatisfaction with out-of-date curricular began to be felt in the early fifties of this century even in the advanced countries of the West, and this reached a crescendo of self-criticism after the launching of the *Sputnik I* by the USSR, providing a suitable climate of opinion for the wholesale revision of the curriculum. Among the notable attempts in this direction may be cited the Chemical Bond Approach (CBA) and Chemical Study Projects of the USA, the *Science for High School Students* and the *Senior Science for High School Students* brought out by the Nuclear Research Foundation within the University of Sydney, New South Wales, Australia, and the Nuffield Foundation Project of the U.K. Early in 1962, many individual school teachers and a number of organizations in Britain (among whom the Scottish Education Department and the Association for Science Education as it now is, were conspicuous), had drawn attention to the need for a renewal of the science curriculum and for a wider study of imaginative ways of teaching scientific subjects. Finding great opportunities in the situation, the trustees of the Nuffield Foundation set up a science teaching project and allocated large resources to its work.

Under this programme the Nuffield Foundation has produced a series of publications with the avowed objective of achieving a new approach to education through chemistry. In order to avoid rigidity the plan is not based on a single textbook. An attempt has been made to analyze the purpose of a textbook and break it down according to its functions. This has resulted in the preparation of. *Book of Data, Laboratory Investigations,* and the Background Books. The pupils verifies from the *Book of Data* whether his ideas fit into observed facts. He builds his own part of the textbook from *Laboratory Inevstigations* and the Background Books held him form his own library.

The Nuffield publications have been divided into two broad categories: (i) those for the teacher and (ii) those for the pupil. Those belonging to the first category are: *Introduction and Guide, The Sample Scheme Stages I and II (the*

basic course), The Sample Scheme Stage II (A course of options), Collected Experiments, and the *Handbook for Teachers.* Those belonging to the second category are the *Laboratory Investigations Stages I A, I B, II and III (options), The Book of Data* and the Background Books. Under review here is a specimen kit consisting of a representative selection of books from the above, and comprise the following. *Introduction and Guide, the Sample Scheme Stages I and II (the basic course). Laboratory Investigations Stages IA, IB and II,* and six Background books, *viz. Dulton and the Atomic Theory, Chemicals and Where They Come From, The Periodic Table, The Nitrogen Problem and Humphry Davy.*

The *Introduction and Guide* is one of the first books to be produced and contains a discussion of the principles behind the chemistry course and an outline of the sample scheme which is expanded in the book.

The Sample Scheme Stages I and II (the basic course): The course is divided into three stages. The first stage which is intended to cover about two years (11-13 years) with one double-period a week, is introductory and exploratory. The second stage covers the next two years and a term (13-15 years) with one double-period and a single-period per week and is concerned with the ideas Schemists use, such as the atomic theory, structure and energy. The third stage contains a number of optional topics for use during a part of the final year. Each stage is divided into topics which vary in length from about a week to six-eight weeks. The topics are themselves divided into sections, the time required for a section varying between one single and two double periods. In each section a 'suggested approach' for the introduction of the subject is given, the apparatus and exact details of procedure for the experiments listed are detailed and suggestions for homework are also provided.

This book is therefore entirely different from textbooks with which we are familiar in India. In fact one can say that it does not set out any 'fact for the pupil to read and learn' instead it makes him 'do and draw his own conclusions'. The laboratory investigations consist of punched loose sheets which the pupils could tag on to their files. It is suggested that the pupils write a record of their work on blank sheets inserted to face each printed page. As the pupils will be building up their own textbooks and will often want to look back and remind themselves of what ideas and conclusions have already come out of their investigations, the record is required to be as accurate and as complete as possible. The printed page gives the objects of the experiments and the practical details and also the kind of things one should look for while one is doing the experiments, asks questions intended to help the student to think out the meaning of what he sees. All that he needs to do is to write the answers on the blank pages opposite the questions numbering the answers to match the questions. (Not every experiment has been provided with a printed sheet).

The background books as the name suggests are intended to give the pupils the necessary background informations

required for a proper understanding and appreciation of the work that they would be carrying out in their classrooms They are very well written and copiously illustrated and could form an excellent library of supplementary reading material.

The entire approach is novel, and if put into practice with enthusiasm and vigour is bound to yield the expected results. The books should form a part of the library of every school and educationist interested in secondary science education, especially chemistry.

C. RADHAKRISHNAN

Biology : *A Textbook for Higher Secondary Schools* Section 4 and 5. P. MAHESHWARI AND MANOHARLAL National Council of Educational Research and Training, New Delhi 1966. pp 129, Rs. 3.50

The first three sections of this book, already published were reviewed in these columns in the earlier issues. Sections 4 and 5, just released, deal with 'Plant and Animal Physiology' and 'Self-perpetuation or Reproduction'. In its nine chapters, Section 4 gives the student the details about various aspects of the 'Plant and Animal Physiology'. Perhaps for the first time in the Indian textbooks for high school students, physiology is dealt with in such details especially among the animals. Wherever possible, the topics are dealt with in an integrated manner, particularly in the chapters 'On Being Alive,' 'Transport and Circulation', 'Respiration and Provision of Energy', 'Excretion', 'Water Economy', 'Growth and Development', and 'Responsiveness and Coordination'.

Section 5 deals with reproduction in plants and animals in two different chapters. Of particular interest is the Chapter 48 where human development is dealt with. Facts about Development, Artificial Insemination, Parental Care, Hormones and Reproduction, and Multiple Births are dealt with in an interesting and simple way. The details of reproductive system were given in Section 3 in the chapter on Mammals.

Like all the other sections these sections are also profusely well illustrated with a few colour drawings. Sections 6 and 7 on 'Heredity, Evolution and Adaptation' and 'General' have also been published. It will be reviewed in the next issue.

S. DORAISWAMI

A Review of Some Approaches to Physics Teaching

BINA GHOSH
A. K SINHA
B D NAGCHAUDHURI

THE huge, almost frightening expansion of science that has occurred in our time has made a tremendous impact on our educational programmes. Learning and its effective applications to society have become complicated problems. The school curriculum that was prepared a hundred years ago to satisfy the academic needs of those days is now obsolete. To keep students abreast of the new concepts and ideas of science a change in the pattern of teaching is necessary. This pattern should be oriented to augment the scientific, technological and economic growth of a country and at the same time to give the student the basic scientific knowledge which would help him in his vocation and in his day-to-day life.

Physics is one of the main science subjects and society depends to a great extent on its inventions and discoveries. But science educators throughout the world have found it difficult to prepare a syllabus covering the whole area of physics. They have concluded that to frame a syllabus certain topics must be selected, after proper scrutiny, from the vast field of physics but the coherence of the subject should be preserved And, to give the curriculum an effective shape, with this should be combined the insights and experience of physics teachers. As a result, new pilot projects for physics teaching have been instituted in many countries and syllabuses have been modernized. To develop a new system of physics teaching in schools, attempts have been made in progressive countries like the U.S.A., the U.S.S.R., Australia, and many others. We shall now discuss the progress of these projects.

I PSSC Physics

The Physical Science Study Committee is the combined work of university and secondary school teachers in the U.S.A. The project was started in 1956 under the patronage of the National Science Foundation and was aimed at students who took up physics for the first time and who were drawn mostly from the upper half of the school.

The project combined the experiences of teachers, scholars and other specialists in the field The Committee selected subject-matter and organized it as a powerful medium of learning, both in and outside the classroom. Instead of giving a fragmentary knowledge of everything, the committee wanted to select suitable topics with the deepest meaning and the widest applicability.

The materials prepared by the Physical Science Committee are:

1. Textbooks
2. Laboratory guides
3 A set of new and inexpensive apparatus
4. A large number of films
5. Standardized tests
6. A series of paperback books
7. Teachers' guides

The course is divided into four parts:

a) The Universe
b) Optics and Waves
c) Mechanics
d) Electricity and Atomic Structure.

The Universe includes time and measurement, space and its measures, functions and scaling, motion along a straight path, motion in space, mass and the elements, atoms and molecules, the nature and measurements of a gas

Optics and Waves begins with how light behaves, reflection and images, refraction, the particle model of light. introduction to waves, waves and light, interference, light waves.

Mechanics deals with Newton's laws of motion, motion at the earth's surface, universal gravitation and the solar system, momentum and the conservation of momentum, work and kinetic energy, potential energy, heat, molecular motion and conservation of energy.

Electricity and Atomic Structure includes some qualitative facts about electricity, Coulomb's law and the elementary electric charge, energy and motion of charges in electric fields, electric circuits, the magnetic field, electromagnetic induction and electromagnetic waves, exploring the atom, protons and matter, waves, quantum systems and the structure of atoms.

The logic of the subject has been maintained throughout the course. Concepts and ideas are placed in order, so that the earlier materials are used to clarify the material that follows. The course also aims at familiarizing students with the concepts The laboratory programme includes 50 experiments and ten demonstrations. The apparatus for the experiments is available in kit form. The student is provided with a laboratory guide book which contains necessary instructions. The book also directs the student's attention to important points by raising questions. The teachers' guide book contains detailed information regarding laboratory experiments, solutions of problems and other necessary information. The committee plans to produce nearly 60 films. The films will lessen the load of the teacher and are produced for various pedagogical purposes. The course has ten achievement tests (two per part) and two comprehensive tests. The tests are objective in nature.

II Physics in the U.S.S.R.

A state council was set up in Soviet Russia in 1919 to reform science education at school level but the major work

of reform started in 1957. In post-graduate classes, the study of pedagogics, psychology, logic and methods of teaching was made compulsory. As a result the number of skilled teachers increased sufficiently.

Education in the Soviet Union is compulsory now for students of age group 7-18 years. The schools are co-educational and there are 30 students in each class. We shall give here a brief outline of the project

The aims of the secondary school physics course in the U.S.S.R. are:

1. To give the pupils a framework of knowledge in physics
2. To provide a certain range of technological information.
3. To develop certain practical skills in laboratory work, household tasks, and to help the students to do things for themselves and to develop technical creativeness and imagination.
4. To develop in them a materialistic outlook and an understanding of the physical pattern of the world on the basis of physics.

The course begins for the elementary stage and is intended for the age group 13-18. It is done in two phases: the first in the eight-year school (grades VI to VIII, 249 periods), the second in the senior grades in the eleven-year secondary school (grades IX to XI, 382 periods). Grades VI and VII have two lessons a week, grades VIII and IX, three, grade X, four; and grade XI, three.

The syllabus for each grade is as below.

Eight-Year School

Grade VI Elementary physical phenomenon, physical quantities and their measurements; properties of solids, liquids and gases; rudiments of the structure of matter; elementary heat.

Grade VII. Mechanical motion and friction, composition of forces and equilibrium, work and energy mechanisms; heat/work; change of state, thermal expansions

Grade VIII Sound and light; rudiments of current electricity; resistance, voltage, work and power of electric currents, electromagnetics; rudiments of radio reception; principle of atomic structure.

Eleven-Year School

Grade IX Mechanics; uniform motion; Newton's laws of motion; elements of statics; parabolic and circular motion; universal gravitation. work and energy; mechanical vibrations and waves; motion of liquids and gases.

Grade X. Molecular physics and heat (fundamentals of molecular kinetic theory, structure of matter, heat, work and internal energy; properties of gases and liquids in relation to their internal structure; fusion and crystallization; evaporation; boiling and condensation; properties of steam and thermal engines). Electricity (electrical charge and field current in metals, electrolytes and

gases; semi-conductors; magnetic field and electromagnetic induction).

Grade XI. Electricity (alternating current, electromagnetic vibrations and waves, production and use of electric power). Optics (photometry and geometrical optics, wave and quantum properties of light). Atomic structure; atomic energy; the electron envelopes of the atom, radioactivity, composition of atomic energy; atomic power; tracer atom radiation; radio activity.

During both the stages the students are given theoretical and practical instruction. The secondary physics course has an experimental bias. In this course students are given practical home task. Experiments are given in such a way that these become an integral part of the study. The curriculum also includes film shows and excursions. The experiments prescribed in the book are easy and inexpensive The teacher is not provided with a guide book.

III The Nuffield Foundation Science Teaching Project

The project was set up in 1961. Its objectives are to make science intelligible and accessible to pupils of all kinds in schools of all kinds, and to make it a useful tool, both intellectually and practically. The first phase of the project was devoted to the teaching of science in the age group 11-16. Teaching materials—books, films and apparatus—were developed. The whole project was a synthesis of the work of a team of practising teachers.

The entire course has been divided into two levels : Ordinary or 'O' level and Advanced or 'A' level.

The 'O' level course is for students in the age group 11-16 and the purpose is to give preliminary knowledge in science to all category of students. It is a five-year course and starts from the conception of materials and molecules. One five-unit syllabus is given below.

Year I

1 Materials and molecules (exhibition, crystal, weighing)
2. Making a microbalance (a class experiment with simple materials)
3. Rough measurements (weighing, timing, statistics)
4. Looking for a law of levers (a simple series of experiments)
5. Investigations of springs
6. Air pressure and molecules (barometers, gas models)
7. Measurements of a molecule (surface tension experiments, oil film experiments)
8 Energy (a first look at energy)

Year II

1. Forces (turning effects, magnets)
2. Electric circuits (lamps, switches, ammeters, a series of class experiments)
3. Electric currents (conduction of liquids and gases, electron streams)
4. More forces (weight, friction, continued from Year I)
5. Energy (energy changes, power)

6. Heat
(measurement and effects, temperature, molecular model)
7. Heat transfer
(experiments on conduction, convection and radiation)

Year III

1. Waves
(wave behaviour with models, ripple)
2. Optics
(images and rays, instruments)
3. Motion and Force
(informal preparation for Newtonian dynamics)
4. Molecules in motion
(molecular models, behaviour of a gas)
5. Electromagnetism (extensive class experiments with magnetic field, current force, meters motors, electromagnetic induction)
6. Cells and voltage
(introduction to voltmeters, model power line)
7. Electrostatics
(charges, fields and forces, electron streams)
8. A fruitful theory
(teaching the use of a theory)

Year IV

1. The physical basis of Newtonian mechanics (force, mass, acceleration, weight and gravitational field, inertia, momentum, kinetic energy)
2. Kinetic theory of gases
(models, simple derivation and predictions, estimate of molecular diameter)
3. Universal conservation of energy
(heat as a form of energy, universal conservation)
4. Power
(measurement of pupils' power)
5. Electricity
(voltage, current and power)
6. Electrons
(properties of electron streams, the Millikan experiment)

Year V

1. Motion in an orbit
(central acceleration and satellites)
2. Electrons in orbits
(electron streams and magnetic fields, measurements of e/m, atom model)
3. The Grand Theory
(Planetary astronomy and the development of theory)
4. Oscillation and waves
(S.H.M. alternating currents, waves)
5. Interference of light waves
(diffraction, Young's fringes, grating and estimates of wavelength, spectra)
6. Radioactivity
(An experimental study)
7. Waves and particles
(photo-electric effect, X-rays and crystals, electromagnetic spectrum, photons and waves, matter waves, atom model).

The 'A' level course runs simultaneously in the same age group for talented students. No syllabus for this course is given. In the 'A' level course, more stress has been given to the technological implications of science.

The project published a Teachers' Guide to Experiments, and a Questions Book.

Examinations are considered as a helpful part of the course and special evaluation programmes have been designed for this purpose.

IV Pilot Project on the Teaching of Physics—UNESCO, IBECC, San Paulo, Brazil, 1963-64

The objective of the project was to find out new methods and techniques for physics teaching in Latin America. The topic chosen for this course was The Physics of Light. In this course students themselves have to perform laboratory experiments. Eight kits, containing materials for a large number of simple experiments have been developed. The shortage of teachers posed a severe problem in the introduction of these experiments in over-sized classes. To overcome this problem self-instructional materials have been developed. This *self-instructional or programmed instruction text* will ensure on the part of the student, an active attitude and immediate comprehension of the subject during study. To avoid experiments involving expensive and elaborate equipment, short silent films and long sound films are used. The use of 'educational television' has also been suggested. Television classes, showing an expert teacher performing the experiment, will serve as examples to average teachers.

A programmed instruction text in five units is given below.

1. Experiments and graphs
2. Some fundamental properties of light
3. A particle model for light
4. A wave model for light
5. Electromagnetic waves—photons.

The project developed:

1. Eight kits of inexpensive laboratory equipment
2. Twleve short silent films (average time 4 to 5 minutes each)
3. One 16 mm film with sound (Title: Light....is it waves? Duration: 30 minutes).

Eight television programmes also supplemented the course. The whole project concluded with a regional seminar on 'New methods and techniques in physics teaching'.

V The Harvard Physics Project

The Harvard Physics Project consists of scientists and high school teachers from all parts of the U.S.A. They have been working together since July 1964 to develop during three years the instructional materials needed for a new kind of physics course for secondary schools. It is hoped that after it is finalized the course will appeal to a wide variety of students, from those who are science-oriented to those who are shy of the subject.

The project attempts to treat physics as a systematic and fundamental science and tries to establish coordination with other branches of science.

The new course will be centered on a solid introduction to physics, including some of its recent developments. The main content is organized under seven general headings:

Unit I. Concept of motion
,, II. Motion in the heavens
,, III. Conservation and chaos
,, IV. Waves and fields
,, V. Models of the atom
,, VI. Nucleus

The Project physics course is mainly divided into two parts :

a) Basic course
b) Supplementary and complementary materials.

The basic course provides basic text, associated laboratory work and demonstrations, audio-visual materials, programmed instruction, examinations and a Teachers' Guide.

The Harvard project criticizes the PSSC project on the following grounds.

1. The PSSC course is too long and too difficult for many of its intended students. It demands a fairly sophisticated control of mathematics.
2. It errs in avoiding technological applications.
3. It emphasizes classical and modern mechanics without paying any attention to the developments in astronomy which preceded classical mechanics.
4. It is particularly weak in terms of laboratory experiences with modern electrical circuits and devices.

VI The Programme of the Organization for Economic Cooperation and Development of Europe—A Modern Approach

The aim of the OECD programme is to bring the secondary curricula in line with modern developments in the scientific disciplines.

The course begins with the concept of atoms, molecules and electrons. The argument for this is that students nowadays are aware of these terms. So teachers should begin the course from the children's point of interest. Next, the emphasis is placed on mechanics. Teachers are advised to teach mechanics as a branch of science and not as a branch of applied mathematics. Too much stress should not be laid on numerical examples. Maintenance of close contact between teachers of physics and chemistry has been advised. One syllabus, which has put more stress on the modern developments in science, is given below.

1. The particle nature of matter, general ideas of difference between atoms, molecules and electrons.
2. The beginnings of an understanding of the basic concepts and laws of mechanics, with emphasis on the physical significance of the concepts.
3. The simple properties of gases and vapours, an idea of temperature and pressure as a phenomena of the particle in motion, states of matter and change of state in terms of aggregation of atoms and molecules; chemical bonds.
4. Measurement of temperature and the transfer of heat, the laws of thermodynamics; the energy supply available in nature.
5 The structure of atoms, electrons as carriers of electricity, electrostatics, thermonics; electromagnetism, magnetism.
6. Mechanical, acoustic and electromagnetic vibrations.
7. Light as electromagnetic radiation; geometrical optics; diffraction interference; emission and absorption of light; simple ideas of quantum theory; emission of X-rays.
8. Radioactivity; the structure of the nucleus; nuclear reactions, equivalence of mass and energy,

an elementary introduction to relativity.

VII **The Science for High School Project, New South Wales, Australia**

This project under Dr. H. S. Wyndham has introduced a new concept of education in Australia. The objective of the project is to prepare Australian boys and girls to live better in a scientific age and to understand better the world of tomorrow which is theirs.

Science for High School is written for use over a wide range of age from 12 to 15 years. The 'Senior Science' is meant for age groups 16+ and 17+, i.e., it is a two-year course, and each book is devoted to a single subject.

The unabridged edition of *Science for High School* is intended for those taking their school certificate at the 'advanced' level. An abridged edition has also been designed for use of the pupils following the 'ordinary' level course. The students will receive five science instruction periods a week and the course will lead to the School Certificate.

Another noteworthy merit of the course is that it contains all the branches of science, such as physics, chemistry, biology, etc., which are treated in an integrated form and not compartmentalized.

The proposed syllabus, which includes most of the modern developments of science, is given below.

1. The Universe — the solar system; galaxies; gravitational field; the atom universe, elements; molecules; electric field; solid, liquid and gas; electricity, the planet earth; the scientific method.
2. Matter and energy; the effects of heating matter; particles of matter, diffusion; what happens during change of state? Particles, motion and temperature; the sizes of particles; the kinetic theory of matter.
3. More about heat — conduct of heat; the star sphere; the celestial time on earth; past geography of the earth; heat is very important in geography; heat is important in agriculture; heat energy in the kitchen and in the pressure cooker
4. Convection in the air; formation of cloud; the weather map.
5. Electric energy; electric charges; electrophorus; electric current; voltage; resistance; electric current through liquids; magnetic effects of an electric current; the voltaic cell; electric currents in nerves.
6. Waves—water waves; reflection and refraction of waves; light as a wave motion; sound as a wave motion.
7. Forms of energy and machines—machines, motion, particular movement; energy due to position; energy of strain; forms of energy, energy transformation; the machine; the simple machine, what machines do for us.
8. Gravitational attraction and movement; what is a force; gravitational forces; motion under the action of the weight-force; measurement of mass; movements.
9. Satellite motion — putting a satellite into orbit; weightlessness; calculation of approximate satellite speed, some satellite experiments; meteors and meteorites; cause of moon craters.
10. Pressure — the earth's atmosphere, atmospheric pressure; fluid pressure acts in all directions; fluctuat-

ing pressure, measurement of air pressure; atmosphere thins out with height, pressure in liquids, Pascal's principle; buoyancy; fluids in motion.

11. Matter and forces between particles — conduction of electricity, melting point, hardness, malleability and ductility; boiling point; the elasticity of substances; explanation of strain and stress in materials.
12. Speed, acceleration and force; the meaning of speed, velocity, acceleration; the acceleration due to gravity; uniform acceleration; what causes an acceleration? Newton's First Law, Newton's Second Law; weight; gravitational unit of force; air resistance.
13. Newton's Third Law; action and reaction — examples; reflection of particles; momentum; crash effect, unit of momentum; conservation of momentum; proof of conservation of momentum; how a rocket works; relative velocity.
14. More about energy — mechanical work; potential energy, kinetic energy; kinetic energy of reaction; spinning objects.
15. Heat energy; quantity of heat; measuring with heat units; specific heat; theory of heat; explanation of some common heat effects in terms of the theory of heat; what was the purpose of Joule's work?
16. Measuring electricity, electric charge, electric current; potential difference; electric power; electrical appliances in the home; potential difference and resistance; loss of energy by a current; moving charges produce magnetic fields, making an electric compass, magnetic fields; what makes an electric motor spin? Sources of electric power.
17. Electrons in the service of man — alternating current, electronics, conduction of electricity through gases.
18. Forces between particles — surface tension, field, the centre of the earth.
19. The electromagnetic spectrum, detection of radiant energy, radio and television; frequency and wavelength, further properties of waves, detection of radiant energy

VIII Recent Developments in Science Teaching in Scotland

A group to modernize science teaching in the school was set up in Scotland in 1963. Scottish secondary education begins at the age of about 12 years The group tried to reform the traditional school physics syllabus to bring it nearer to the present day. Traditional materials and euipment were removed and replaced. The syllabus deals with the following topics· (1) the physical basis of Newtonian mechanics; (2) the kinetic picture of heat flow; (3) waves of interconversion and conservation of energy; (4) electromagnetism; and (5) atomic physics

The laboratory experiments were completely changed. Some of the experiments are qualitative in nature but students are expected to find out the values of physical constants in some cases.

IX The Applied Physics Course, New York

The aim of the course is to give

technical education to those students who will not proceed beyond the high school level. It deals with the technical applications of physics more than with theoretical physics. As for example, the hydraulic press has been explained without explaining Pascal's Law. Mathematics has been minimized. One of the syllabuses is given below.

1. Electricity—uses, safety and supply
2. The automobile—different parts and their functions
3. Different types of engines — gasoline, diesel, jet, rocket, steam, steam turbine
4. Hobby satisfying devices—phonogram, recording camera, etc.
5. Energy and power
6. Atomic energy — origin, production, peacetime use, international control
7. Airplane — different parts and their functions, control safety
8. Electronics — different parts of radio receiver, television, radar, etc.
9. Temperature—refrigeration, domestic and industrial heating process and control, air conditioning
10. Health — different technical methods and tools used in medical procedures
11. Hearing
12. Vision

X The Science Manpower Project — Teachers' College, Columbia University, New York

The aim of this course is to provide a basic understanding of the concepts, theories and principles of modern physics

The outline of the course is presented in eight areas:

1. Foundation of mechanics
2. Wave motion
3. Heat energy
4. The nature and propagation of light
5. Electricity, magnetism and electronics
6. Nuclear energy
7. Relativity.

The problem-solving approach to instruction has been stressed. A problem is frequently approached by way of questions asked by the students or the teacher. Discussion, demonstrations, individual laboratory work, film shows, tests and examinations are processes to help the educational progress.

In the place of the traditional examination, the self-evaluation test has been suggested. Here the student will evaluate his own progress. Thus he will be less grade-conscious and will try to eliminate his own shortcomings. The teacher will test the students before and after instruction. He will also judge as to how well a given student follows directions and carries out his various assignments in individual and group activities.

The process of evaluating a student's growth will help a teacher to review his programme of instruction. He will note his own successes and wish to repeat them. He will note his failures and try to eliminate them. At the same time he will include new discoveries in his programme of instruction which, like science itself, will be a fluid and changing thing.

Discussion

The methods of teaching physics developed in the various countries during the last fifty years have been dis-

cussed above. In all these projects, the planners have tried to show that physics is not a mere collection of facts. The approaches to physics teaching are different for different groups but the goals are the same. The pioneer work in the field was done by the Physical Science Study Committee in the U.S.A. This work was followed by similar developments in biology and chemistry. The project expanded its boundary beyond America and developed reformation work in under-developed countries like Africa. Students for the PSSC course were drawn from the upper half of the school, and not from the elementary classes. The new technique adopted in the course was to allow children to do experiments themselves. Another new feature was the involvement of teachers in the evolution of the curriculum. As students can learn best through their experiences in the laboratory, similarly teachers are the best persons to point out the virtues and vices of the existing teaching methods. Teachers are provided with a guide book suggesting new methods of teaching along with solutions of the problems they face during this teaching. Teachers are a busy community and get little time to think over this change. The project considers that the teachers' guide book is more important than the students' textbook. However, the PSSC project does not throw any light on elementary science, and the age group for whom it is intended has not been mentioned. The experiments suggested in the course are sophisticated and expensive.

The Nuffield Foundation Project was founded by the Science Masters' Association in the U.K. The courses have been tested in more than 170 schools for more than three years. The textbook has no place in the Nuffield project; on the other hand students are provided with question books. No doubt, a textbook for students is less important than a teachers' guide, but the need for a textbook cannot be completely obviated.

The Russian project mainly aims at the age-group 13–18 years. It starts from Class VI and goes up to Class XI. The students' textbook is written in a lucid way and experiments are presented as part of a consistent course. The experiments prescribed are easy and inexpensive. There is no provision for a teachers' guide.

The Wyndham project in Australia was designed to provide a complete science course for secondary school students in Australia. The project tried to establish coordination between all branches of science, and the book is written in an integrated form. The teachers' manual provides all necessary hints along with solutions of problems. The book is meant for all the four years, i.e., for a wide range of age groups, and the disadvantage of the book is that it supplies all the facts without any instructions as to how the book is to be used. The experiments used in the book are very weak and the whole course is textbook-based.

Apart from the PSSC, there are other parallel projects on in America. The Harvard Physics Project is one of them, but it is still in the experimental stage and sufficient information is not available. The Applied Physics course in New York is meant for students who do not proceed beyond the high school. The project deals with the physics of everyday life, and from that point of

view it is unique. Similar projects are going on in Europe too, but sufficient information about them is not available.

With the new curricula, new methods of assessment must replace the old systems of examination. Consequently evaluation procedures were considered by most of the groups as part of the curriculum, and all these projects are associated with specially designed examination systems. However, none of these attempts have devised a perfect solution, though all of them show some advance from the older pedagogy in both content and methodology.

The success of a curriculum is measured by the extent to which it can fulfil the needs of the student and satisfy the demands of the society in which he lives. Reform of science education, particularly physics teaching, has therefore, been the concern of scientists and teachers in many countries. The educational planners of today are trying to educate the younger generation in the wider outlook of the modern scientific age and are attempting to close the increasing gap between the science and technology of today and science pedagogy in schools.

The Development of a Mathematics Curriculum for Indian Schools

J. N. Kapur

FOR the last one hundred years, the development of the mathematics curriculum in Indian schools has proceeded very slowly. For the very minor changes that have been made over this long period, there was sufficient flexibility built into the system. The changes that have to be brought about during the next ten years will however exceed in order of magnitude the changes that occurred in a hundred years or more. For these revolutionary changes, the curricular development programmes need vigour, purposefulness, clear thinking and large-scale experimentation and would involve a large number of mathematicians and administrators at all levels, and huge funds.

In other countries, a great deal of effort has already been made in this direction. In India, it has just begun with the setting up of a number of study groups in different universities. Ultimately, lakhs of rupees and thousands of persons are likely to be committed to this programme. It is therefore necessary that we should be clear about the objectives of the whole programme, understand its implications and try to find the best way to achieve the goals. In any such effort, spending money may be easier than spending thought, but the latter is equally important.

One fact emerges at once. In view of the rapid developments in mathematics, science and technology, any curriculum can only be a stepping stone to a better curriculum, and the sequence of steadily improving syllabi is likely to be an infinite sequence.

Components of a Curriculum

The following are some of the components of a complete curriculum in any subject:

1. The formulation of objectives of teaching and a philosophy of education in that subject for different levels of education and for different groups of students.
2. Syllabi consistent with these objectives and detailed synopses for the same.
3. Model textbooks based on these

syllabi.

4. Workbooks and supplementary experience materials
5. Teacher's guides.
6. Audio-visual aids like charts, models, films, etc.
7. Experiments for students.
8. Try-out of the material under controlled conditions in a large number of schools, using the results as a feedback to improve the material still further.
9. Material for school mathematics clubs as extra-curricular aids to help curricular development.
10. Suitable syllabi for teachers who are going to handle the new curricula.
11. Textbooks for teacher-training courses
12. Syllabi for the in-service training of teachers, especially for refresher courses and summer institutes for school teachers.
13. Suitable textbooks for summer institutes.
14. Improved evaluation techniques for assaying the effectiveness of new curricular material.
15. Means built into the curriculum for its constant review and improvement.

The Present Position in India

1 Some objectives are stated in some of the syllabi, but these were laid down about a hundred years ago. These have to be re-examined in the light of recent developments in mathematics and its applications. An integrated philosophy of mathematics education has yet to emerge.

2. Every state has a syllabus of its own. Though the contents of these syllabi are slightly different, the spirit is the same. New syllabi have been framed by (a) the NCERT textbook panel (b) the Central Board of Secondary Education, Delhi (c) the Council for the Indian School Certificate, (d) the NCERT's Science Education Department (e) the UNESCO group attached to NCERT, but attempts have not been made to relate these to clearly formulated objectives or to prepare detailed synopses for the guidance of textbook writers.

3. Few textbooks based on the new syllabi have been prepared. A number of new textbooks on algebra have been produced to meet the requirements of the new syllabus of the Delhi board. The mathematics editorial board of NCERT is likely to produce three or four books during the next four or five months. The NCERT has also produced a book for Class VI.

4. Only a very few supplementary workbooks are available.

5. No teachers' guides are available Individual teachers are left completely to their own resources. They do not read even the textbooks, which they use merely to make collections of problems Teachers know some standard techniques for solving standard types of problems and repeat these year after year with their students. The concepts are never emphasized.

6. There are no charts, models or films for illustrating mathematical concepts. This is not surprising, since for 'drill', audio-visual aids are not necessary. Such aids are however very urgently needed for the improvement of school mathematics. The present author is trying to develop such aids.

7. Normally we associate experiments with laboratory sciences like physics, chemistry, biology, etc. In mathematics also there should be experiments; these experiments will be with numbers, with shapes in geometry and with other physical objects having number characteristics. There are enough mathematical laws to be verified in the laboratory of arithmetic and geometry, of the same type as physical and chemical laws which are verified in physics and chemistry laboratories. In fact, quite a number of these laws can be discovered by the children themselves. Very little work has been done in this direction. The author is trying to develop such experiments for school children

8. So far there has been almost no 'experimentation' with new ideas in Indian schools The UNESCO project has been concerned with trying out new material with Class VI of some Delhi schools. The author has himself tried out some new ideas with Class IV children at IIT Campus School, Kanpur. In other countries hundreds of schools and thousands of children have participated in trying out newly developed curriculum materials.

9. Mathematics clubs practically do not exist in Indian schools. One school in Madras has a Number Club and has been holding exhibitions every year. But this is an exception. In the U.S.S.R., schools are very active and series like 'Popular lectures in mathematics' and the 'Library of mathematics circles' have been published. Mathematicians like Yaglom, Uspenky, Bollyanks and others have participated in writing these books. In the U.S.A., we have the New Mathematics Library.

10. There are no books for teachers of mathematics, on any new programme.

11 There exist books on the techniques of teaching, but none for teacher-trainees.

12. A large number of summer institutes for secondary school teachers have been held all over the country. It is desirable that a great deal of thought is given to the preparation of a syllabus for them.

13. In the summer institutes mostly SMSG books have been used. There are few Indian books available, and these few have not been used.

14. The NCERT has done a good deal of work in developing tests for the old curriculum. The same or even greater effort will have to be put in for developing tests for new curricula.

15. We have boards of study which periodically revise syllabi, but very often these boards consist of senior persons who are averse to any change whatever.

The Need to Formulate Objectives of Teaching Mathematics

It is very often presumed that there is no need to give any thought to this problem since. (i) it will not serve any purpose except to produce high sounding phrases; (ii) we already know enough about these objectives, and after all they should not have changed during the last hundred years.

There are, however, serious reasons why these presumptions are unrealistic and why a study of this subject may be rewarding. These are:

1. There is not as much public support for the study of mathematics in India as there is in countries like the U.S.A., U.K., France,

U.S.S.R., Hungary, etc. In India the laboratory sciences and technology possess greater glamour, mathematics is not attracting the best students in the country. All this requires a thorough probe and one of the means for this can be the study of the philosophy of mathematics education.

2. The scientists and the engineers support the study of mathematics as they need it as a tool. The majority of the population however feel that all that an average educated person needs is simple arithmetic and they see no reason why every child should be taught algebra, geometry, coordinate geometry or calculus. Even if forty or fifty thousand children are going to need all this in later life, why should we burden the remaining five crore of children with this stuff? To answer these questions effectively, a clear formulation of the objectives of teaching mathematics is necessary.
3. Mathematics has enjoyed a 'privileged' or 'sheltered' position in the school curriculum. There is great pressure to include more physical sciences, more biological sciences, more social sciences and more languages. Clarity about objectives is necessary to justify the time allotted at present to mathematics in the school curriculum and, if it is considered necessary, to ask for more time.
4. The very need for curricular changes can be justified only in terms of objectives of teaching.
5. The quantity of mathematics has exploded at an exponential rate. It is not possible to survey a significant part of this in the school curriculum. The courage to discard is necessary, and a proper selection of the material to be taught is absolutely necessary. This selection depends upon the objectives laid down.
6. Mathematics is not only a 'product', it is a process also. It is not only a 'knowledge', it is also an activity. Its 'static' part is important, its 'dynamic' part is equally vital. Not only are mathematical facts to be taught, but the method of arriving at these facts is also to be communicated. All this requires rethinking over the goals of mathematics education.
7. The mathematics curriculum has to be designed for four broad classes of persons: (a) those who are going ultimately to become professional creative mathematicians (b) those who are later going to use mathematics as a tool (engineers, physicists, economists, industrial mathematicians, computer scientists, etc. (c) those who are going to become teachers of mathematics (d) the average citizen who needs it for his daily business, for its intellectual and cultural value, and for its help in understanding the discoveries made in the various sciences. We have to investigate whether the goals for all these are the same. A discussion of the objectives will clarify whether the goals for all these groups can be met by the same curriculum or whether some differences in the curriculum are necessary.
8. During the last twenty or thirty

years, a great deal of research has been done in the psychology of learning. All this has to be carefully incorporated in a mathematics curriculum. The goals must incorporate as much as possible of this knowledge, at least as an ideal

9. We have to distinguish clearly between goals which can be realized immediately and those which can be realized ultimately under a certain set of ideal conditions. There has to be a careful blending of idealism and realism. The objectives of the curriculum should lay down the ideals, the curriculum should approach them in a phased programme.

10. The need for integrating the teaching of mathematics with teaching in other disciplines like physics, chemistry, etc., also emphasizes the need for the study of objectives

11. Greater integration between various branches of mathematics like algebra, geometry, arithmetic, etc. is needed.

12 The need to unify concepts for simplifying the teaching of mathematics itself stresses the need for thinking about objectives and curriculum.

13. The present curriculum has arisen simply by growth, by a process which has been described as being analogous to the geological accumulation of one layer piling up on top of the other with something getting squeezed out every now and then It should be possible to vastly improve this state by deliberate, purposeful thinking.

14. The number of applications of mathematics is growing so fast that it is hardly possible to extrapolate ten or twelve years in advance, but this is the period after which the children may be asked to apply mathematics This shows the necessity of giving training in the spirit of mathematics rather than in specialized techniques We have to decide on the type of curriculum that will serve this purpose.

15. The new curricula have to place more emphasis on thinking and less on memory How this can be achieved requires a great deal of thinking.

Some Objectives of Mathematics Teaching

The NCERT publication *Position of Mathematics in India* lists the following objectives as occurring in Indian syllabi:

(a) Elementary level

Ability to perform necessary computations; accuracy, precision, speed, neatness, etc., ability to represent verbal statements by diagrams and symbols; ability for logical thinking; ability to estimate measurements and to conceive approximations to answers; ability to solve common problems related to the home and social life; ability to develop interest in some vocation.

(b) Secondary level

To develop an understanding of those mathematical concepts, facts, terms, procedures, symbols, relationships and principles which are needed to solve

everyday problems, to develop such qualities as: (a) working with speed, precision, accuracy and neatness; (b) estimation and approximation; (c) capacity to apply mathematics to simple concrete situations.

The UNESCO project lists the following objectives:

(a) *Middle level*

To enable the pupils to understand and use mathematical concepts, principles, processes, skills in their day to day activities; to meet the vocational needs of the pupils; to develop in the pupils a scientific outlook; to prepare the pupils for the secondary stage; to enable pupils to learn other sciences meaningfully and thoroughly; to initiate the pupils into modern developments in mathematics.

(*b*) *Secondary level*

To make the pupils learn the modern developments in mathematics; to prepare the pupils for advanced study of science and technology, to develop the powers of logical thinking, abstract thinking and generalization, to acquaint the pupils with a systematized knowledge of methematics; to enable the pupils to acquire techniques of problem solving; to develop in them an attitude of investigation and critical analysis.

Goals of School Mathematics and Nature of Mathematics

An objective of teaching mathematics should be to make clear the nature of mathematics itself. This concept can run like a unifying thread throughout the whole curriculum. The nature of mathematics is reflected in the following characteristics.*

1. *Mathematics is a Dynamic Intellectual Enterprise*

The curriculum should reflect the dynamism of mathematics. It should show mathematics as an exponentially growing subject. One way can be to include some topics developed in the twentieth century, preferably after 1940 or 1950, in the school curriculum, e.g., some results in number theory, linear programming, inventory theory, replacement, some combinatorial problems, etc., which can be included in the school programme. The object is to make the student feel that mathematics is not static and that it is possible for him to understand a result established very recently and that he can also contribute to the onward march of mathematics. (The present author is making a collection of the results proved after 1900 which can be included in the school curriculum. He would be glad to receive suggestions for the same) The present curriculum does not include anything done during the last two hundred years and this can be hardly exciting to children in the modern age. In physics, chemistry and biology, they read of recent discoveries; they should do the same in mathematics

Secondly, mathematics is primarily an intellectual subject. It should not be presented as a collection of rules which have to be applied mechanically

* For a detailed discussion of these, see J N. Kapur, *The Nature of Applied Mathematics*, (Agra University Extension Lectures) or the book *The Nature of Mathematics* by the same author, which is to be published shortly

to a large number of examples. The whole curriculum should be built round interesting and intellectually challenging problems. It should lead on to intellectual awakening rather than to a dulling of the intellect. Mathematics is also an enterprise. The student should feel all along that he is engaged in an intellectual adventure. He is not a passive verifier of results, rather he should be encouraged to engage himself in a voyage of discovery. The 'process' in mathematics should be even more important than the 'product'. The products are used to illustrate the process, the process is used to obtain products.

2. *Mathematics is Logical*

Logic is the essence of mathematics. Mathematics draws necessary conclusions from explicitly stated assumptions. The student must study a number of axiomatic systems. They may not be deep, but they must be logically correct. He must understand the nature of proof. For this purpose, local axiomatization may be preferred to global axiomatization. After a good mathematical training, the student must be able to detect faulty deductive reasoning, and differentiate between definitions, axioms and postulates and validly drawn theorems deduced from axioms. He must develop the analytical faculty to break up problems into 'what is given', 'what has to be proved' and 'the steps of proof'.

3 *Mathematics is a Study of Sets with Structures*

The basic concepts of sets and structures (algebraic, order and topological) have been unifying concepts in mathematics. At the school stage, mostly algebraic and order structures are studied. The student must be clear about these structures for natural numbers, for integers, for rational numbers, for real numbers and for complex numbers. He must be able to see a close relationship between algebra and geometry. Inequalities must play an important part in this study. The student must feel at every stage that he is not studying isolated facts, but properties of mathematical structures.

4. *Mathematics is a Study of Patterns in Number and Space*

The student must develop a sense for noticing patterns when he comes across these. These may be in the various laws of number systems or in sequences and series or geometrical figures. He must be able to perceive designs and symmetries when he sees them. Number and space intuitions have to be strongly built. A student must be able to exploit symmetrics in number and geometrical patterns.

5 *Mathematics Deals with General Structures*

The intuition must be developed strongly. By looking carefully at a number of particular structures, the student should be able to perceive a general structure. He must also see the necessity of proving the validity of the general principles by appealing to principles like the principle of induction or the deeper principles of logic. In every case he must see the generality of the results of algebra and geometry. He must see that every theorem can have an infinite number of particular illustrations and, further, that

no amount of experimental verification can prove the theorems. He must realize that the certainty of scientific results depends to a great extent on the use of the mathematical method.

6. *Mathematics Deals with Abstract Structures*

Abstraction is essential in mathematics. The school curriculum, however, must be motivated by very concrete situations and there must be plenty of concrete examples of every mathematical system But the goal of abstraction must not be given up. A feeling for abstraction must be developed, though this should not be overdone. At least, no abstraction should be introduced unless it is ensured that the children can see its point.

7. *Mathematics Deals with Precise and Elegant Structures*

Elegance is an elusive term, but the student must at the end of the school programme be able to distinguish between elegant and inelegant mathematics. He must also be able to make precise statements and to detect loose statements.

8. *Mathematics Deals with Deep Structures*

Although in a school we cannot study the subject in great depth, the student should feel that in dealing with successive number systems, he is going to increasingly deeper structures, and he must be inspired with the desire to study deep structures

Mathematics Education and Applications of Mathematics

A large number of students at the school level are interested in becoming engineers, chemists, physicists, economists, psychologists, lawyers, business men, and so on Mathematics education must meet their needs The following applications of mathematics can be developed in the school curriculum.

a. Elementary applications of arithmetic in measurement of lengths, weights, time, work, etc., and in shipping, banking, insurance, taxes, national planning, national projects, welfare schemes, etc. All these applications have to be greatly emphasized at the elementary level and the problems have to be related to the children's experience. There may however be other problems which serve a social purpose i.e., which give the children knowledge about, and a sense of pride in, the national achievements in various fields. All problems should however be realistic and should give a correct picture of the state of things.

b. Making simple algebraic models of physical situations and then solving them. These may involve not only classical problems, but also problems from fields like inventory, or replacement, and economic and psychological models and so on.

c. Applications of probability and statistics. These show the student the possibility of applying mathematics to education, medicine, agriculture, physics, chemistry, economics, etc. Here examples should be drawn from as many different fields as possible Another advantage of this course would be that it can give the student some experience of inductive inference. The course may or may not go up to this level, but if it does, it should not be difficult to construct elementary examples for the students.

d. Another application which has become important in school mathematics is linear programming. A knowledge of linear inequalities and their graphs can be *used to solve graphically two-dimensional* linear-programming problems. It may however be difficult to do the simplex method at school, but the teachers at least should know it well.

e. Another field of application which has been tried at an advanced level in schools is that of computer programming. In India, computers are fast becoming popular and some elementary concepts of approximation and programming are within the reach of our students. As a first stage, the use of the slide rule and concepts of orders of magnitude can be popularized at the high school level.

f Graph theory and its applications can also be taught, the concepts are simple and the applications are widespread.

If we can do an effective job of improving our curricula, room can be found for these and other applications.

There is general agreement that some applications should be taught in school There may be differences as to how many of these should be taught, and by what method One method which is generally accepted is that these applications should be spread throughout the course and students should do each one as soon as possible. Another view is that these applications can be grouped together in one course which can be taught like algebra or geometry Such a course may consist of selections from the following topics:

Laws of supply and demand (from economics), linear programming, sets and logic, Boolean algebra and electrical circuits, elements of probability, elements of statistics, graph theory and its applications, etc.

Modernization and Indianisation of the Mathematics Curriculum

There is a great deal of talk about introducing 'modern mathematics' or the 'new mathematics' in our new school curriculum on the same lines on which it has been introduced in western countries The mathematics introduced there is modern or new only in the sense that it is new to the schools. The modernization consists in the discovery that some of the concepts which were being taught at college level can be taught at school level also. Of course, the methods of presentation have to be different and a great deal of research and experimentation has to be undertaken to find the appropriate methods and levels of presentation We may also seriously consider another type of genuine modernization: we should undertake reasearch to find out whether some results in mathematics obtained after 1940 or 1950 can be introduced in schools. In fact, even the new presentation of subjects like geometry has led to intense thinking and has given us results which were not known in the nineteenth century.

Another aspect we can consider is the Indianisation of the curriculum Quite a number of Soviet books in school mathematics start by glorifying the achievements of Russian mathematicians. This practice has been responsible in some measure for the greater interest being taken in mathematics in Soviet schools. We can follow the same practice, not in a narrow chauvinistic

sense, but with the object of inspiring our students to greater creative efforts in mathematics. This can be achieved in a number of ways:

1. We may emphasize the importance of zero and the place value system. All over the world, these are being emphasized in the interest of mathematics itself. We can highlight these achievements of ancient Indian mathematicians even more. By working in the Roman or Greek system of numeration the children will easily realize that the achievements of the ancient Hindus have been fundamental to modern civilization.

2. We can include in our regular courses a number of problems by Jain *munis*, Bhaskaracharya, Brahmagupta and others.

3. We may include a brief account of ancient India's contribution to mathematics, as a part of the course.

4. We may include the contribution of contemporary Indian mathematicians in the school curriculum.

5. We may encourage the schools to celebrate the birthdays of Indian mathematicians of modern times like Ramanujam, Ganesh Prasad, Pillai, Vijaya Raghavan, Vaidyanathswamy and of some of the living Indian mathematicians. We may supply their portraits with brief biographical sketches for use in schools. Some of these can be included in textbooks also.

6. We may expose students to some of the more active research workers so that they feel that research in mathematics is being done in India.

7. We may follow the Russian pattern in starting every textbook in school mathematics with a preface highlighting the contribution of ancient and modern Indian mathematicians.

Development of Audio-visual Aids

As has been said earlier, mathematics is taught in too abstract a fashion in our schools. To make the presentation more concrete and interesting, immediate attention is to be given to the development of audio-visual aids, like the following:

1. **Charts.** Standard sets of charts illustrating the basic mathematical concepts have to be developed for all classes. Those interested in the development of the school curriculum may undertake to design model charts for this purpose.

2. **Models.** For the first three classes, standard kits of toys may be made. Instead of imagining that 3 horses and 2 horses make 5 horses, the child should not only use symbols on paper, but he should handle physical objects. At present the teachers have to make *ad hoc* models. Generally, because of their inertia, few models are shown in the classes. It will therefore be desirable to have standardized kits for this purpose.

3. **Films.** The Indian Mathematical Society, the NCERT and the Films Division of the Government of India can cooperate to produce films. Mathematicians can write the scripts for these films.

Development of Experiments on School Mathematics

In physics, chemistry and biology, students perform experiments with their own hands and this increases their interest in these subjects. If similar experiments can be developed for mathematics, it will help to create

enthusiasm for the subject. Some model experiments are listed below:

1. Experiments in arithmetic, e.g., discovering number patterns, reversed subtraction process, reversed addition process, the sieve of Erosthenes, etc.

2. Experiments in geometry, e.g., verifying most of the theorems in geometry, construction of regular solids, etc.

3. Experiments in topology, e.g., cutting Mobius strips, soap bubbles, etc.

A complete set of experiments for each school class can be easily prepared

The Role of the Study Groups

The study groups formed by the National Council of Educational Research and Training can do the following:

1. Consider the objectives of teaching mathematics for different groups at different levels.
2. Prepare model syllabi for all classes, keeping in mind the present conditions. They can also try to study the goals to be aimed at in the next few years.
3. Study the contents of the present topics to be retained in detail, and discuss the best way of presenting these, keeping in mind the modern concepts of structures and sets.
4. Decide on the new topics to be included and prepare detailed synopses for each of these. The synopses should include a study of motivation, audo-visual aids, sample lessons, typical exercises, examination papers, etc.
5. Integrate all the topics, old and new, in a unified structure.
6. Try out the new ideas in selected schools and improve the new materials with the help of the feedback received.
7. Prepare charts and models, and scripts for possible films.
8. Make a comparative study of foreign mathematics education projects and draw from them lessons which may be useful to India.
9. Develop sets of experiments in mathematics for schools.
10. Consider the preparation of teachers for teaching the new curriculum effectively.

Lavoisier and Some Recent Work on Energy Release for Industry and Agriculture

N. R. Dhar

THE discovery of the neutron fission of uranium to barium and other elements in 1939 by Prof. Otto Hahn, with liberation of tremendous energy according to the Einstein equation: $E = Mc^2$, where E=energy, M=mass decomposed, and c=the velocity of light, has led to fabulous activity and expenditure all over the world for obtaining atomic energy for the use of man. But uranium occurs on the earth's surface only to the extent of 4 gm per ton of the earth's crust; thorium, another fissionable element, is only three times more abundant. Moreover, only 0.7 per cent of uranium (U_{235}) is actually utilized in energy production. And although 12 new trans-uranium elements have been synthesized in the last 26 years, the consensus of expert opinion seems to be that even on the basis of the most optimistic assumption about the future rate of nuclear development, until 1975 the contribution of atomic power to growing energy demands will be marginal. (*The Petroleum Handbook*, 4th edition, Shell International Petroleum Co., Ltd., London, 1959, p. 20). Hence, the world energy requirement for man and his industries is being met and is likely to be met in the future by the oxidation of wood, coal, petrol, natural gas, diesel oil, lignite, peat, etc.—products of photosynthesis by absorption of solar light.

We have therefore to thank Lavoisier for supplying us the clue for obtaining our energy supply from oxidation of organic matter.

More recently, Dhar and co-workers have proved that all materials produced by photosynthesis and those derived from them can be incorporated in the soil for fixation of atmospheric nitrogen and improvement of land fertility by their slow oxidation in air on the soil surface. We shall however discuss this later. First let us consider Lavoisier's life, career and achievements.

Brilliant Career in the Service of Science

Lavoisier was an eminent scientist and a clever thinker with a broad education and culture. He rendered immense service to French science, agriculture and economics by his discoveries. As far as the progress of the present civilization is concerned, it is difficult to point out a scientist who has rendered

greater service to man than Lavoisier. This is because of Lavoisier's classical discovery that energy release takes place from the combination of the oxygen present in the air with organic materials created by the plants which absorb solar light for photosynthesis. Lavoisier's work was highly quantitative and practical in nature. He set apart a piece of land on his estate at Vendome near Blois for agricultural experiments In 1771, he even studied the water supply of Paris

Antoine Laurent Lavoisier was born in 1743 at Paris where his father was a leading barrister. Antoine's mother, a rich woman, died when he was a child, and he was brought up with great care and affection by his aunt, who remained single to devote herself to her task.

Lavoisier was deeply interested in science from his very boyhood. He was trained in chemistry by G. F. Rouelle (1703-1770) at the Jardin du Roi, in mathematics and astronomy by La Caille, in botany by Jussieu, in geology and natural history by Guettard. Thus he had a broad and sound education in the different branches of science. The French Academy of Sciences offered him a Gold Medal in 1786 for his essay on the best method of street illumination. In 1775, he was appointed a member of the Gunpowder Committee by the French Government. The French gunpowder used during the American Revolution from 1775 onward to overthrow the British rule was prepared by Lavoisier and was much superior to the British variety In 1780, Lavoisier was recognized as having contributed to the triumphs of France and its army. He became a member of the Commission for the Introduction of the Metric System in 1790, and in the following year he was appointed Commissioner to the Treasury. During this period he presented a Report on *Richesse Territoriale du Royaume de France* (The Territorial Richness of the Kingdom of France.) He was a great pathfinder.

Overthrow of the Phlogiston Theory: Law of Conservation of Mass

In his remarkable paper on "The Nature of the Principle That Combines with Metals during Their Calcination and Increases Their Weight' (in 1775) he had announced that this principle is simply "the purest and the most salubrious part of the air, so that if the air which has been fixed in a metallic combination again becomes free, it reappears in a condition in which it is eminently respirable and better adapted than the air of the atmosphere to support inflamation and the combustion of substances". This was the death blow to the Phlogiston Theory.

The fundamental basis of Lavoisier's new chemical philosophy is contained in the following statement:

> We may lay it down as an incontestable axiom, that in all the operations of art and nature nothing is created, an equal quantity of matter exists both before and after the experiment, the quality and quantity of the elements remain precisely the same, and nothing takes places beyond the changes and modifications in the combinations of these elements Upon this principle, the whole art of performing chemical experiments depends, we must always suppose an exact equality between the elements of the body examined and those of the products of its analysis.

Regarding the Phlogiston Theory, Lavoisier recorded in 1783 as follows:

> Chemists have made of phlogiston a vague principle which is not rigorously defined and which consequently can be adapted to explain everything for which it is required. Sometimes this principle is heavy, sometimes it is not; sometimes it is free fire, sometimes it is fire combined with an earthly element; sometimes it passes through the pores of vessels, sometimes they are impenetrable to it; it explains at the same time causticity and non-causticity, transparency and opacity, colour and the absence of colour. It is a veritable Proteus that changes its form every moment

Physiology and the Science of Nutrition

Even more important and striking were Lavoisier's experiments on animal nutrition, for it was he who by exact scientific methods first established the identity of the processes of combustion and respiration.

The first step in demonstrating the identity of the processes of combustion and respiration was Lavoisier's proof that the *gas-sylvestre* of Van Helmont and the 'fixed air' of Black was a compound of oxygen and carbon to which, because of its acidic character, he gave the new name of carbonic acid. Since carbonic acid was a product of respiration, as well as of combustion, the next step in the argument was the natural inference that breathing was essentially a process of combustion in which the oxygen of the air united with the carbonaceous matter of the blood.

The modern area of nutrition was opened by Lavoisier in 1780. He was the first to apply the balance and the thermometer to the investigation of the phenomena of life, and declared: *"La vie est une fonction chimique."* The work being done in nutrition today is but the continuation of that done more than a century ago. Lavoisier and Laplace made experiments on animal heat and respiration. Liebig (1803-1873) was a pupil of Gay Lussac in Paris in 1822 and Gay Lussac (1778-1850) was associated with Baron Berthollet (1748-1822), who was a friend and supporter of Lavoisier. Thus, Liebig became acquainted with their work. Liebig's conception of the process of nutrition fired the genius of his countryman, Carl von Voit, to undertake the painstaking researches which laid the foundation of his Munich school. These have been repeated and extended by his pupils, notably by Rubner, and others the world over. Thus, the knowledge transmitted personally from master to pupil, to be in turn extended and elaborated, had its seed in the intellect of Lavoisier. It was he who first discovered the true importance of oxygen gas, to which he gave its present name. He declared that the life processes were processes of oxidation, with the resulting evolution of heat. It was he who first made respiration experiments on man, the results of which were briefly described in a letter to M. Terray, written from Paris in November 1790. There is no existing record of the apparatus with which Lavoisier obtained those important results, which are in strict accordance with the knowledge of our day. We today know more details, but the fundamental fact that the quantity of oxygen absorbed and of carbon dioxide excreted depends principally on (i) food, (ii) work, and (iii) temperature, was established by Lavoisier within a few years of his discovery that oxygen supports combustion. Writing in 1849, Regnault and Reiset say: *"Les recher-*

ches modernes ont confirme ces vues profondes de le 'illustre savant'"

Quantitative Analysis of Organic Substances

Although Lavoisier had established the fundamental principles of combustion and organic analysis, by which carbon is determined as carbon dioxide and hydrogen as water, his analysis of sugar, alcohol and acetic acid are inaccurate because he had not developed the art fully. His determinations of carbon are much too low and those of oxygen too high, as is seen from the following table.

TABLE

	Actual percentages			Percentages found by Lavoisier		
	Carbon	Hydrogen	Oxygen	Carbon	Hydrogen	Oxygen
Sugar ($C_6H_{12}O_6$)	40.0	6.7	53.3	28.0	8.0	64.0
Alcohol (C_2H_5OH)	52.2	13.0	34.8	29.0	16.6	54.4
Acetic acid ($C_2H_4O_2$)	40.0	6.7	53.3	25.0	6.3	68.7

However Lavoisier indicated the correct method of organic analysis which Liebig improved. Wurtz declared in 1868 that chemistry was a French science founded by Lavoisier of immortal memory.

His Execution

During the French Revolution, a large number of aristocrats as well as men holding important positions in the government were put to death by the revolutionaries. Among those executed were twenty-eight Fermier Generaux, that is, tax collectors. Lavoisier, who was a Fermier General, was also sent to the guillotine

The chief cause which led to the tragic end of Lavoisier was the great hatred of the common Frenchman of that time for the Fermiers Generaux, who were rich and mismanaged the finances of France. Also, Lavoisier was the heart and soul of the French Academy of Sciences, which was set up by the French king, Louis XIV, and began its work in 1666 Moreover, Louis XIV had befriended Lavoisier on many occasions.

Lavoisier's Support for the French Academy of Sciences

Many of the difficulties faced by Lavoisier were due to the attitude of the revolutionary Convention towards the Academy of Sciences. Along with other monarchical institutions of the time, the Academy was suspected of incivism and its destruction was already being arranged. Lavoisier, who had become the Treasurer of the Academy, now found himself confronted with new troubles. The salaries of the Academicians, many of whom were old and in straitened circumstances, were in arrears Lavoisier advanced money from his private purse in certain of the more urgent cases. However, the Academy continued to hold its meetings as usual until the spring of 1792, when it was suspended.

At that time Lavoisier had taken refuge in the arsenal where he had a laboratory built at his own expense. But later he gave himself up to the revolutionaries. He was tried by a jury and was found guilty of conspiring with the enemies of France. A courageous friend and a citizen, Halle, read a

detailed account of the discoveries of Lavoisier and his services to France before the Revolutionary Tribunal, but the presiding officer, Coffinhal, when asked to spare a man of science, said: *"La Republic n'a pas besoin des savant"*. (The Republic has no need of savants.) Lavoisier was condemned to death and was guillotined on 8 May 1794.

As Lavosier had rendered eminent services to France and he was besides a very remarkable man in the history of science, this crime profoundly shocked the intellectual world. Every scientific body in Europe expressed its sense of shame and sorrow After the fall of Robespierre, this sorrow was felt all over France, too. On 22 October 1795, Lalande pronounced an *eloge* (eulogy) on Lavoisier before the Lyceum of Arts. Other solemn funeral ceremonies were also held in Lavoisier's honour.

Lavoisier was a man of perfect method and he preserved all his manuscripts After his death, they were religiously guarded by Madame Lavoisier, from whom they passed to her niece, Madame Leon de Chazelles. Lavoisier's furniture, laboratory equipment, books and most of his papers, which had been confiscated, were returned to Madame Lavoisier in 1796. She died childless. She had considerably helped her husband by illustrating books and translating German and English papers.

It has been reported that the remains of Lavoisier were taken to the cemetery of the Madeleine. A marble bust of Lavoisier was erected in 1801 at Versailles. A bronze statue was also erected behind the Madeleine. It showed the famous mercury experiments of Lavoisier. This metal statue along with other statues, including those of Pelletier and Caventou, the celebrated pharmacist of Ecole de Pharmacie, were removed and taken to Germany during the Nazi occupation of Paris.

Arthur Young, a British scientist who visited Lavoisier at the arsenal in October 1787, found him "splendidly lodged and with every appearance of a man of considerable fortune Madame Lavoisier, a woman of understanding, that works with her husband in his laboratory, was then translating Kirwan's Essay on Phlogiston". According to Fourceroy (1755-1809), Lavoisier performed his experiments many times before his colleagues and invited their rigorous criticism. He also took young men of promise into his laboratory and trained them in research. Prof. Marcelin Berthelot (1827-1907) states that Lavoisier was a soft, kind but prudent and well-informed scientist, who managed his affairs very satisfactorily.

Lalande, who was a friend of Lavoisier and knew him well, has said: "Lavoisier was of large stature; affability and penetration were displayed in his countenance, his behaviour was mild, civil and polite and his activity knew no bounds."

Even during the dark days of 1793, Lavoisier, active, optimistic and courageous as ever, strained every nerve to continue the work of the Academy. True to his trust, he pleaded for those of his colleagues, who had been reduced to poverty by the decree of the Convention:

> Citizens! the time presses; if you allow the men of science, who composed the defunct Academy to retire to the country, to take other positions in society and to devote themselves to lucrative occupations, the organization of sciences will be destroyed and half a century will not

> suffice to regenerate the order. For the sake of the national honour, in the interests of society, as you regard the good opinion of foreign nations, I beseech you to make provision against the destruction of the Arts, which would be the necessary consequence of the annihilation of the Sciences.

About this time, the great luminaries in the sciences, the most brilliant of any age or country, Condorcet, Monge, Coulomt, Laplace, Berthollect, Vauquellin, Gay Lussac, Thenard, Alex Brougniart, Cuvier, Lamarck, Geoffrey St. Hillaire, Arago, Ampere, Poisson and others also flourished in Paris.

It is likely that the jealousy of A.F. de Fourceroy and Guyton de Morvenu was utilized by the revolutionaries against Lavoisier. Marat, who was highly influential and a member of the National Convention, dabbled in chemistry and wrote an article on fire which was very crude and was denounced by Lavoisier as the Director of the Academy of Sciences. Marat later incited the adversaries of Lavoisier to action by the statements like the following:

> Lavoisier, the supposed putative father of all the discoveries, which are noised abroad, having no ideas of his own, fastens on those of others but is incapable of appreciating them, he abandons them as readily as he adopts them and changes his systems as he does his shoes!

In his paper, the *Ami du Peuple*, Marat is even more furious:

> I denounce this coryphaeus of the charlatans, Seur Lavoisier, son of a land grabber (gripple-sol), chemical apprentice, pupil of the Genevese stock-jobber, Fermier General, regiseur of powder and saltpetre, administrator of the Discount Bank, Secretary of the King, Member of the Academy of Sciences . Would to heaven that he had been strung to the lamp-post The electors of La Culture would then not have to blush for having nominated him

It appears, therefore, that Lavoisier was not only a very able scientist and administrator but was also essentially a very good and just citizen bent on improving France by the application of science and technology. Unfortunately, he fell a victim to the eternal fight, specially during the national upheaval, between the rich and the poor who are always in a majority.

It is interesting to record that in the *Memoir on Respiration* by Lavoisier and Seguin, published in 1798, the year of the revolution, they stated that the lot of the manual worker had to be improved, payment to labour had to go up, and that wise institutions should equalize fortunes.

It may also be mentioned that some foreign scientists, specially Germans, have not been fair to Lavoisier; for example, Girtanner, who lived in Paris for some time, stated in 1786:

> Lavoisier is Fermier General and has much business connected with this so that acess to him is difficult, as I have myself found I am told that, with his great wealth and little time, he has many of his experiments arranged and executed by others

Similarly, Dorfman called him, "a businessman in the worst sense," but there is certainly no evidence that in his public and private life, Lavoisier was otherwise than highly scrupulous and honourable. Regarding his scientific achievements the great German scientists like Baron Liebig (1803-1873) and Wilhelm Ostwald (1853-1932), have not been eulogistic. Liebig stated:

> He discovered no new body, no new natural phenomenon; all the facts established by him were the necessary consequences of researches that had preceded his own His immortal

> service consisted in endowing the body of science with a new spirit; but all the members of that body were already present and correctly united

Ostwald expressed himself in the same vein.

Oxidation of Organic Matter and Nitrogen Fixation

Now we may discuss some recent researches into energy supply from oxidation of organic matter, the clue for which was first given by Lavoisier.

Dhar and co-workers have experimentally observed that organic substances like sugar, starch, cellulose, lignin, straw, grasses, leaves, peat, coal, mobiloil, oils and fats, etc., photosynthesized by light absorption, undergo slow oxidation on the soil surface into titania, zinc oxide, iron oxide, aluminium oxide, silica, etc., and in this process the nitrogen of the air is fixed. In the case of glucose as sugar, the following changes take place in soils as in the animal body:

$C_6H_{12}O_6+6O_2=6HO_2+6CO_3+676$ cal.

This energy can break up water molecules into atomic hydrogen and the CH radical :

$(H_2O+112K \text{ cal} =H+OH)$

The atomic hydrogen readily combines with the molecular nitrogen absorbed on the soil surface and forms ammonia. As this process requires energy, light energy falling on the system can increase nitrogen fixation and land fertility. In this process we have discovered that phosphates are of paramount importance and micro-organisms are not necessary in nitrogen fixation. For the first time in the history of science light energy has been found to be useful for improving soil fertility

Moreover, we have experimentally established that the soil organic matter (humus) is oxidized to a greater extent by air in the presence of nitrogenous fertilizers and manures than in their absence, but when straw or other organic matter is added to the system, the loss of humus is markedly retarded and fixation of atmospheric nitrogen occurs.

Our researches show clearly that organic substances produced by photosynthesis and aided by calcium phosphates are the chief suppliers of soil nitrogen and are responsible for crop production in the world.

The oxidation of organic matter on soil surface is much more comprehensive and universal than animal body oxidation, because, in the animal body, soluble carbohydrates, starch, oils, fats and proteins undergo slow oxidation with liberation of energy, but in the soil or sand surface not only these materials but more complicated substances like cellulose, peat, lignin, lignite, coal, hides, hoofs, horn, animal blood, etc., are slowly oxidized.

Moreover, for feeding the world population of 3,200 million human beings, 32×10^{14} kilo calories per annum are needed, assuming that one million kilo calories is the average annual consumption per human being. On the other hand, botanists have estimated that approximately 13,750 million tons of organic carbon are added annually to the earth's surface by photosynthesis as cellulose; assuming that half of this is oxidized per annum, the caloric liberation is 6875×10^{14} kilo calories, and this may lead to the fixation of nearly 200 million tons of atmospheric nitrogen.

Oxidation of Nitrogenous Substances and Nitrogen Loss

It has also been proved by our researches that nitrogenous compounds undergo the following changes when applied to soil

$$\text{Proteins} \rightarrow \text{amino acid} \xrightarrow{+O_2} NH_3 \xrightarrow{+O_2} NO_2 \xrightarrow{+O_2} NO_3$$

All these oxidation reactions are markedly accelerated by light absorption and increase of temperature. Ammonium nitrite, an unstable substance is formed as an intermediate product in these reactions It is well known that ammonium nitrite breaks up readily, with evolution of heat, as in the equation.

$$NH_4NO_2 = N_2 + 2H_2O + 718 \text{ K. cal}$$

This reaction is also enhanced by light absorption. This explains why the recovery of nitrogenous fertilizers and manures in crop production is low and never exceeds 50 per cent.

In recent years these researches have been successfully repeated in other countries and their importance realized.

Scientists—Benefactors of Humanity

I am concluding this article with the following lines written by the immortal Lavoisier just before his death:

> We shall close this memoire with a consoling reflection It is not required, in order to merit well of humanity and to pay tribute to one's country, that one should participate in brilliant functions that relate to the organization and regeneration of empires The scientist in the seclusion of his laboratory and study may also perform patriotic functions. He can hope by his labours to diminish the mass of ills that afflict the human race and to increase its enjoyment and happiness; should he by the new paths which he has opened have helped to prolong the average life of man by several years or even by only several days, he can aspire to the glorious title of benefactor of humanity.

First Synthesis of a Protein

H. N. Rydon

CHINESE chemists have synthesized crystalline insulin, thereby achieving what has long been attempted with only partial success—the artificial production and purification of a complete, active natural protein. It is a *tour de force* in fundamental chemical research, with no obvious technological application.

A great deal of interest has been aroused by the publication, in a recent number of *Scientia Sinica*, of the details of a total synthesis of crystalline insulin carried out by a group of 21 Chinese chemists and biochemists, working in the laboratories of the Academia Sinica in Shanghai and of Peking University. Readers of *New Scientist* will be aware of similar work which has been in progress for some years in Germany and the United States, and the purpose of this article is to summarize the position.

The structure of insulin, which is a small protein, was established, by degradative methods, by Sanger and his colleagues in Cambridge in 1955. Bovine insulin has the structure shown in Figure 1; in the figure the three letter symbols represent amino-acid residues (–NH. CHR. CO–, in which the R's represent any of 20 different chemical groupings), which are linked together end to end to form the chains known as peptides (. . .NH. CHR. CO. NH. CHR. CO. . .). The molecule contains two such peptide chains, A and B, containing respectively 21 and 30 amino-acid residues. Each chain is terminated at the left-hand end by an amino (NH_2) group and at the right-hand end by a carboxyl (CO_2H) group. The two chains are joined together by two disulphide (–S–S–) linkages and a

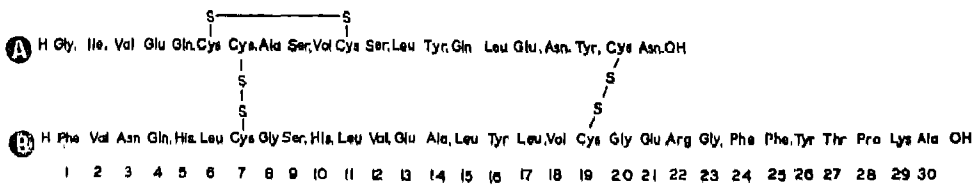


Fig. 1

Reprinted from New Scientist, 30,223 June 1967, 501 · 766-767

similar linkage, between residues 6 and 11, forms a 'loop' in the A chain. Insulins from different mammalian species differ in the nature of some of the amino-acid residues, in sheep insulin residue A9 is glycine (Gly) instead of serine (Ser), while in human insulin residues A8 and B30 are threonine (Thr) and residue A10 is isoleucine (Ile).

The synthesis of such a compound from its component amino-acids is a formidable task. Of the various possible strategies, all three research groups have adopted the simplest, which involves the separate syntheses of the A and B chains followed by their combination to give insulin.

Thanks to the great improvements in methods for synthesizing peptides, which have been made in recent years, the synthesis of the two individual peptide chains presents no difficulties of principle. It does, however, require hard work and great experimental skill owing to the large number of difficult chemical operations involved. The synthesis of a dipeptide from its component amino acid involves between three and six distinct chemical operations (Figure 2).

The synthesis of a peptide containing n-amino-acid residue therefore requires between 2n+2 and 4n+3 stages; the total synthesis of the A-chain of insulin thus involves between 44 and 87 stages and that of the B-chain between 62 and 123 stages. Such syntheses have been carried out by all three groups. The A-chain peptide of sheep insulin was synthesized in 1963 by Zahn and his colleagues at Aachen and by Katsoyannis and his colleagues in Pittsburgh, who also synthesized the A-chain peptide of

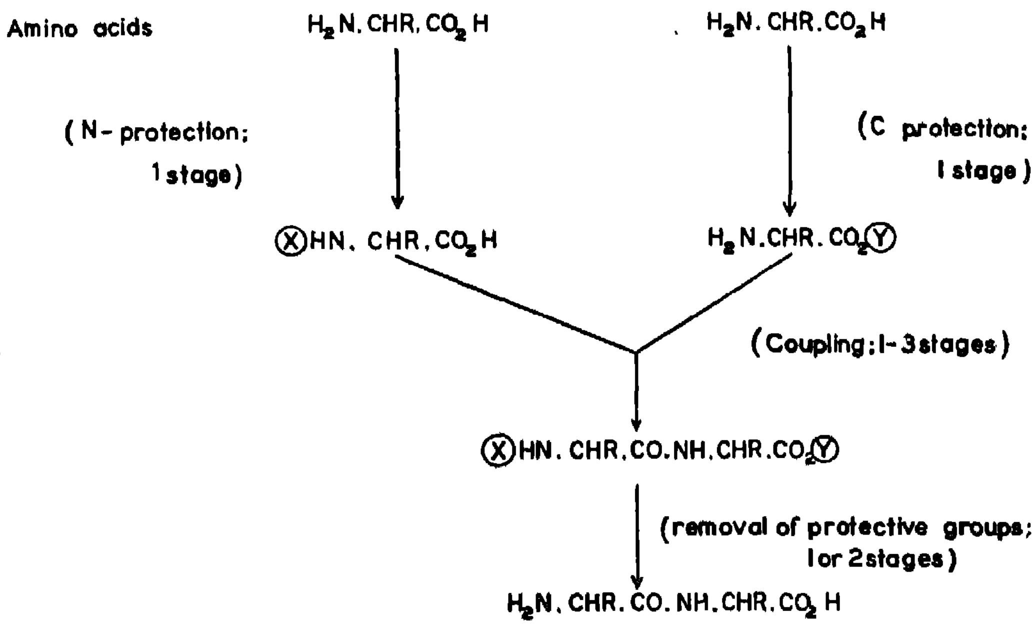


Fig. 2

human insulin in 1966; the A-chain peptide of bovine insulin was synthesized by the Chinese group in 1964. The B-chain peptide of sheep and bovine insulin was synthesized by all three groups in 1963-64, and that of human insulin by the Pittsburgh group in 1966. These syntheses are all in themselves very considerable achievements.

The combination of the synthetic chain polypeptides to give insulin is quite a different matter. It may, at first sight, seem easy to bring together the chains, bearing –SH groups where –S–S– linkages are required in the insulin, and to oxidize the mixture to give insulin, a process which can be represented diagrammatically as in Figure 3.

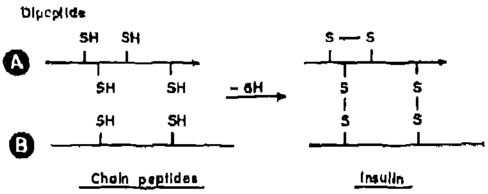


Fig. 3

Unfortunately this is only one of 12 ways in which the two chains can come together and Kauzmannin (1959) calculated that the probability of insulin being produced, rather than one of the 11 other possible isomers, was only 0.04; this calculation neglects combinations of the A and B chains with themselves, and the formation of products containing more than two chains, and it is clear that only a very small amount of insulin can be expected from oxidative combination reactions of this kind. Nevertheless, this is the method used by all three groups.

The first clearly successful recombination of the A and B chains of insulin was carried out in 1960 by Dixton and Wardlaw, who split natural bovine insulin into its component chains and recombined them to give a product shown by bio-assay and immunological methods to contain 1 to 2 per cent of insulin.

The method was greatly improved in 1961 by Drs. Zhang, Lu and Tsou who developed an experimental procedure which gave increased yields (usually 5 to 10 per cent, sometimes as much as 20 per cent); these workers also succeeded in isolating from the recombination product crystalline insulin, which was 76 per cent pure (by bio-assay) and chemically indentical with natural insulin. The Chinese group later (1965) described a procedure giving reproducible yields of 50 per cent and, more recently (1966), a similar claim has been made by the Pittsburgh group.

The first combination of synthetic A- and B-chain peptides to give sheep insulin, in 0.5 to 1 per cent yield, was announced in December 1963 by the Aachen group. A similar combination to give an unspecified yield of insulin was reported by the Pittsburgh group in March 1964. Another publication in July 1964 seems to indicate that the yield was very low (about 0.05 per cent). Very recently (January 1966) the Pittsbugh group announced a combination of synthetic human A- and B-chain peptides to give a 2 per cent yield of insulin. Although there is little real doubt that the activity of these various products was indeed due to the presence in them of insulin, the formal evidence in support of this view is very slender and neither group has succeeded in isolating anything like a pure product.

This is not the case with the work of the Chinese group, who announced the

combination of the synthetic bovine A- and B- chain peptides to give bovine insulin last November (*Scientia Sinica*, Vol. 14, p. 1710) and who published the full details of their work this April (*Scientia Sinica*, Vol. 15, p. 544). Although their yield of insulin, as assessed by biological assay was only 1.25 to 2.5 per cent they nevertheless succeeded in purifying their product fully, eventually isolating crystalline insulin, 87 per cent pure, on the basis of the internationally accepted mouse-convulsion assay. The identity of this crystalline product with natural bovine insulin was fully confirmed by several crucial chemical and immunological methods. This synthesis must, therefore, be held to be the first fully established synthesis of a protein and, as such, must be hailed as a truly outstanding scientific achievement.

The significance of this work is likely to be scientific rather than technological. The length of the synthesis, with the inevitable loss of material at each stage, is such as to make it almost inconceivable that synthetic insulin could ever compete with the natural product, even if the yield in the final combination stage were greatly improved. Scientifically, it is clear that modifications of the synthesis can lead to modified insulins which are likely to be of great value in relating chemical structure to biological activity and also in facilitating X-ray crystallographic studies on the shape of the insulin molecule. However, the greatest scientific significance of the synthesis no doubt lies in the stimulation and encouragement it will provide for work directed towards the synthesis of larger, more typical, proteins, this is truly a seminal piece of work.

Tobacco: Its Effect on the Human System

G. Raju

TOBACCO is the dried and processed leaf of several species of *Nicotiana*—a genus of plants belonging to the family Solanceae to which tomato, potato and *brinjal* belong. At least two species of *Nicotiana* are extensively cultivated all over the world. *Nicotiana tabacum* is cultivated in South America, Mexico and West Indies, and *Nicotiana rustica* is cultivated in Asia, North America, the U.S.S.R., India and several European countries.

Even before the Europeans came to know of its use, tobacco was commonly used by the natives of South America. Columbus saw the Indians of the Caribbean drawing smoke through a Y—shaped pipe called 'tabaca'. This name 'tabaca' was later extended to the plant itself and its products. It was Jean Nicot, French Ambassador to Portugal who sent seeds of the tobacco plant to Catherine de Medici in 1950. After that it was introduced in many European countries, and Nicot gave his name to the genus of this plant and called it *Nicotiana*. The alkaloid product found in tobacco later came to be known as nicotine.

Now tobacco is used widely all over the world. It is smoked, chewed or inhaled as snuff. The use of tobacco has been praised by persons who constantly use it. They say that smoking is a soothing, harmless practice which is conducive to thinking and which serves as a tranquilizer whenever they are disturbed. But the medical men say, on the contrary, that it is harmful to the body and is responsible for the irritation of the throat and lungs. It is popularly believed that tobacco causes loss of appetite, indigestion, palpitation of the heart, shortness of breath, ailments of the respiratory tract, cancer, etc. Some people however exaggerate the ill effects of tobacco without fully knowing the various substances it contains and their effects on the human system.

Let us therefore consider the different substances found in tobacco and their action on the various systems of the human body. The substances found in tobacco and its smoke include nicotine existing in combination with various acids like acetic acid, malic acid and citric acid, pyridine compounds, ketones, aldehydes, tobacco tar, amino-acids like glutamine, glutamic acid, nicotinic acid, nicotinamide, ammonia, carbon dioxide, carbon monoxide, etc.

Some of these substances are beneficial to our body while others are harmful. The useful substances include the amino-acids and the water-soluble vitamins.

Apart from the tobacco tar, the harmful effects of tobacco are primarly due to nicotine. What is this nicotine? It is one of the few liquid alkaloids. It is colourless, volatile and alkaline in solution. On exposure to the sun, it turns brown and acquires the characteristic odour of tobacco. In the tobacco leaf, it remains in combination with acetic acid, malic acid and citric acid. When the leaf is burned, nicotine is liberated.

Nicotine in the pure form is one of the most toxic of all substances and is said to act with a rapidity comparable to that of potassium cyanide. The nicotinic content of one cigar approximates the lethal dose for man. However, swallowed in the form of tobacco, nicotine is much less toxic than would be expected. There are instances in which children have chewed and swallowed cigarettes without any lethal effect, although the amount of nicotine contained in a single cigarette is almost the estimated fatal dose for a child. This is because when nicotine gets into the stomach, only a very small amount of it is absorbed by the walls of the stomach. This small amount actually delays further absorption of this substance and also helps to stimulate the nerve centres to throw out the remaining nicotine. People develop tolerance for a certain amount of nicotine after using it regularly. When used in excess, tobacco reduces the appetite and weakens digestion, since it interrupts the hunger contractions of the stomach.

When tobacco smoke containing nicotine comes in contact with the lungs, the tissues of the lungs directly absorb some amount. Of this absorbed nicotine about 5 to 15 per cent is eliminated in the urine. The rest of it is converted into certain compounds and enters into the system. It has been found that in small doses nicotine has a stimulating effect upon the various centres of the medulla oblongata—the hind brain. It affects the respiratory centre and the circulatory centre resulting in shortness of breath, slowing down of the action of the heart, constriction of arteries and a tendency to vomit. In small doses nicotine produces a mild calming or sedative effect on the higher brain centres. That is why, when disturbed, some people smoke a cigarette and feel calmer

Nicotine also acts on the pituitary gland and causes it to release a hormone called antidiuretic hormone. This hormone hinders the elimation of urine and retains the water in the body. In experiments on animals it was noticed that if they are given an injection of nicotine after being given large amounts of water, they will retain much of the water, for some time. It is said that in the case of human beings the same effect can be observed in the lungs after the subject has smoked one or two strong cigars.

The action of nicotine in constricting the blood vessels is seen clearly in persons suffering from diseases like Buerger's disease. The symptom of this disease is the painful constriction of the small blood vessels in the limbs. It was found that most of the persons suffering from this disease were smokers. If they continued to smoke after the onset of this disease, the blood vessels got constricted still further. Their condition im-

proved when they gave up smoking.

Nicotine acts upon the various ganglia of the autonomic nervous system. The autonomic nervous system supplies nerves to various internal organs and serves to bring about actions that are independent of our will. The autonomic nervous system is composed of two divisions, the sympathetic and the parasympathetic. These two divisions have opposite effects on various organs. If one system is connected with the dilation of the blood vessels, the other can bring about their contraction. Nicotine stimulates the ganglia of both sets of autonomic nerves. It first causes the heart beats to slow down and then speeds them up. It causes an increase in blood pressure and a decrease in the flow of blood for circulation in the skin. This results in a distinct drop in the temperature of the area.

In large doses, nicotine depresses all sympathetic and nerve-relay stations. In this respect it acts like some of the modern hypotensive drugs which help in reducing high blood pressure. It is not used in medical practice to reduce the blood pressure because the margin of safety between a depressant dose of nicotine and its fatal dose is very narrow. Moreover, large doses of nicotine, if injected into the body, depress the hind brain and this is always dangerous and may prove fatal.

Occasionally, in the case of middle-aged or old persons heavy smoking might fog the vision. There are instances of persons, who continued to smoke heavily after this stage, becoming temporarily blind. However, in such cases, normal vision was regained after the patient stopped smoking.

Nicotine may increase the secretion of hydrochloric acid in the stomach. Some believe that this causes or aggravates peptic ulcer, at least in certain cases.

Smoking becomes a habit which people often find hard to break. What are the various factors that contribute to the formation of this habit? We hear people say that smoking gives them pleasure. This pleasure can be attributed to the mild sedative or calming action of nicotine on the central nervous system. It is also said that the carbon monoxide formed in small quantities is capable of producing a slight degree of intoxication. Thus the pleasure of smoking might also be partly due to the mild carbon monoxide poisoning.

Another reason for the formation of this habit is the peculiar flavour which the smoker gets while smoking tobacco. Once he get used to this flavour, he develops a craving for it.

Certain experiments conducted on human beings showed that the substance nicotine itself is involved in the formation of this habit. Some heavy smokers were asked to give up smoking for some time, and during this period they were given injections of nicotine. They reported that the injections satisfied their craving for smoking. Non-smokers, when given the same dosage of nicotine, through injection, found it rather unpleasant. When a person starts smoking, after his first experience with tobacco, he might become dizzy, pale and begin vomitting. After the first few trials he might not get these unpleasant symptoms since our body develops a certain degree of tolerance for nicotine. As far as habit formation is concerned, the above two factors are mainly physiologi-

cal. There is a third factor which is purely psychological. This is connected with the rituals of smoking. The elaborate steps involved in taking out a cigarette and lighting it, and the style of smoking, are enjoyed by the smoker and he would like to repeat them frequently. Besides, smoking a cigarete or a cigar is said to give the smoker confidence to face certain situations, this is again purely psychological.

Thus the absorption of nicotine and the ritual of smoking together produce a certain psychological effect on the smoker. Therefore, when a person suddenly stops smoking, he may feel restless, moody, irritable and may even experience sleeplessness. However, all these symptoms of discomfort are likely to disappear after a few days or weeks if one is really patient and determined not to go back to smoking once again.

Lung Cancer and Smoking

Smoking has been very much in the news, ever since the turn of the century, as a possible cause of lung cancer. At first it was thought that cigar and pipe smoking were chiefly responsible for inducing cancer. But now it is believed that heavy cigarette smoking is responsible for this malady.

Two kinds of evidence have been collected which place the emphasis on smoking as the cause of cancer: (i) statistical, (ii) experimental. The statistical data collected, particularly in the U.S.A., show that there has been an increase both in the consumption of cigarettes and the occurrence of cancer, in recent years. In addition, a high proportion of lung cancer patients were found to be cigarette smokers. Again, these patients were either heavy or chain smokers. Lung cancer is rare among persons who have never smoked. In any country the deaths from lung cancer increase with the amount of cigarettes smoked.

It is surprising that no such connection is found between cigar smoking and lung cancer. It is very likely that some of the substances causing cancer are freed and lost during the ageing process or during the high fermentation to which cigar tobacco is subjected.

Non-smokers too may develop lung cancer due to the constant inhalation of various substances like industrial fumes, the dust from bituminous road surfaces, petrol and diesel exhausts, etc

During some experiments conducted with animals, when materials condensed from tobacco smoke were applied to their skins, they developed cancer. Investigations have shown that a tarry substance found in tobacco called 'tobacco tar' can induce cancer. After the skins of mice were painted with tobacco tar, a high percentage of them developed malignant growth. Tobacco tar, and certain little known and unknown ingredients, which it contains may produce a chronic irritating effect. Inhalations of this type may lead to cancer of the respiratory tract and lungs. In cerain cases, even two per cent of the original tar found in cigarette smoke can develop the cancerous tissue. Of course, our knowledge regarding this aspect of the effects of tobacco is still far from complete.

It should not be inferred from the account given above that smoking tobacco will kill a person, either through cancer or through other ailments resulting from its use. But one thing is

certain: tobacco can very much lower the vitality of a person who constantly smokes, and it can make him susceptible to many diseases. The normal metabolism of a person might be impaired, with the result that he may suffer from ill health throughout his life. In certain cases, it might produce cancer, which often proves fatal unless detected in the early stages.

Reorganization of Practical Training in Physics: II

B. SHARAN

THE objectives of practical training and the ways to achieve them have already been dealt with at length in an earlier paper.* In the present paper are described the general principles of alertness, differences between a scientific observation and a casual observation, methods of accurate measurement, their non-absolute nature or statistical character, and use of different types of means, their relative merits and demerits for choosing the best representative value. The proper way of taking averages—when to take the arithmetical mean of a first or higher power of a quantity—are given at the end. The examples given in the text are merely suggestive, they may be suitably modified according to the standards and degree of maturity of the students.

General Alertness

An intelligent approach often saves a lot of time. Before starting the experiment check that the apparatus is at the desired place, and that all its parts are working smoothly.

Observation and Measurement

An observation should not merely be regarded as tabulation of numbers and reproduction of statements from books. It should reflect personal attention and depict any departures noticed from the anticipated behaviour or any other special points. Some students take observations, notice deviations from the pre-conceived results and, for fear of being wrong, 'cook up' results or copy from others' readings. The attitude of an observer should be to exercise the maximum care and to be keen to discover something new.

Most of the contributions to knowledge have come through keen observation, correlation and deep thinking. Thus, observation is the most vital part of any experiment, for it supplies the evidence in support of or against any theory. Any structure built on weak foundations (weak observations) would collapse sooner or later.

A good experimenter is accurate in his observation and precise in his measurement. He knows enough of the characteristics and contrasting physical properties to identify and mark the boundary of the space in which the

* See **School Science,** March 1967, V.2.

object is situated. The region in which the object is, can be located by scanning part by part. For example, the process of scanning would tell us that on taking out a plug from a standard resistance box, the resistance introduced in a metre-bridge circuit is not only in the resistance box, but includes also the resistance box plus connecting brass pieces, plus the leads.

The success of an experiment depends upon how intelligently one uses his five senses, namely, touch, taste smell, hearing and sight. Quite often instruments are used as aids to the senses. For an accurate observation the observer, the object and the instrument for observation should be in proper positions with respect to each other. Some cardinal principles about a good setting are stated here.

1. It is convenient to have the measuring instruments easily accessible for operation and observation; very often they may need levelling and correct alignment.
2. Observation should involve the minimum of movement—an observer who has to move from place to place cannot take accurate observation. The lag between an operation (the pressing of a key) and the recording of an observation (the deflection of a ballistic galvanometer) will have serious effects in all dynamical experiments.
3. The point of observation should be kept along the line of sight. It is not advisable to place a moving coil galvanometer above one's head.
4 Static conditions are to be maintained, i.e., supports for instruments are to be kept steady and free from vibrations. This is necessary in the case of a balance, a ballistic galvanometer and an interferometer. For special experiments more information and details can be obtained from the accounts of the original experiments given by the scientists who performed them.

The setting for observation An observation is influenced by the object under study, the surrounding instruments and the observer. The reproducibility of the information gained through our senses depends greatly on the precise knowledge and careful separation of the parameters affecting the observation.

A scientific measurement has to be accurate and needs extra care. It is a contrast to a commercial measurement which is least intended to be accurate and therefore needs only a little care. Everyday examples of commercial measurements are measurements of length and mass by cloth merchants and vegetable sellers. *The principle of scientific measurement involves the method of coincidence.* Take, for instance, the determination of the length of a rod. The two extreme edges of the rod are put between two marks on a metre scale, so as to coincide with them and the difference between the reading on the scale gives the length of the rod.

The use of the eyes. The eyes at times observe inaccurately because of the following:

1. Parallax. The division on the scale of a metre and its pointer and the optical centre of the eye are not in one straight line.

2 Resolving power. For example, objects very close to the eyes cannot be seen separately, distinctly. Experiment. Try to read letters written on a sheet of paper, from a distance of 5 cm by putting your nose on the paper.
3. Distinctness. For example, the object may be far off.
4. Strained state of the eye.
5. The unsteadiness of the observer's position

In short, to be able to take readings accurately, the eye should neither be too far off from the scale nor too near it; in both cases it is difficult to read. The best position for the eye is the least distance of distinct vision, i.e., 25 cm.*

These instructions can never be exhaustive. Many decisions have to be taken at the time of the experiment and they rest entirely on the intelligence and power of correlation of the worker. However, an experimenter should always ask himself the following questions:

1. Why am I doing this particular thing?
2. Will it really tell me what I want to know?

These questions may prove to be of immense help in revealing the behaviour of the object under investigation.

A word of caution is necessary regarding the meaning of the phrase 'accurate measurement'. It means that one aims at measuring the best possible value of the quantity sought in spite of disturbing factors. The moment these disturbing elements are known, one tries to control or eliminate them. For such situations there are special statistical remedies like factorial design, Latin squares and randomization.

Statistical Experiments

How many observations to take?

The majority of students have a very wrong notion that the quantities measured are absolute, devoid of error. This is often reflected in their questions like "Sir, how many readings should we take?" and in their recording of experiments where the tabulated results may have four to seven significant figures. The number of significant figures depends more on the figures given in a log table or got by actual arithmetical calculation rather than on their idea of the accuracy attainable. The following criterion may help in deciding the number of observations to be taken. Perform the same experiment at least three times. The second is to check the first, and if they differ, the third is for confirmation. If all the measurements differ from each other, then for a reasonable result more repetitions are required. This process is continued till a large number of readings appear to be scattered about a particular value, each time it is ensured that the experiment is carried out in an identical state. The condition in which all parameters (object + surroundings + observation + time) are indentical, is an ideal to be approached asymptotically; for instance, the time of any two observa-

* It may be worth while to give the results of two differing observations by two different persons and ask the student to explain the differences by his own observation

tions can never be the same.

Length, mass and time are the three fundamental units of Newtonian Mechanics and the fact that their measurement is not absolute but always involves some uncertainty can be illustrated by the following experiments.

Measurement of length. Two experiments are described here. In the first students may be asked to take at least ten readings to find out the distance between two points marked on a sheet of paper by means of a travelling microscope. To give an idea about the nature of variation in readings the author reproduces his own measurements in Table 1. They were taken on a comparator (least count 0.001 mm) to get the distance between two layer lines of an X-ray rotation photograph of AIPO taken with M_o K_x radiation

TABLE 1

Measurements for the distance between two layer lines of an X-ray rotation photograph

S. No.	*Layer Line = + 1*	*Layer Line = + 1*	*Distance between the layer lines*
1.	6.3170	5.9511	0.3659
2	6.3160	5 9490	0.3670
3.	6 3207	5 9488	0.3719
4	6.3055	5 9472	0.3583
5.	6.3278	5.9515	0.3763
6.	6 3241	5.9522	0 3719
7.	6.3210	5.9616	0.3594
8.	6.3200	5.9459	0.3741
9.	6.3219	5.9537	0 3682
10.	6 3260	5.9453	0.3807
11.	6 3248	5.9520	0.3728
12.	6.3241	5.9543	0.3698
13.	6 3250	5.9494	0.3756
14	6.3195	5.9494	0.3701
15.	6.3190	5 9459	0.3731
Total	**94.8124**	**89.2573**	**5.5551**
			Mean Difference =0.3703

In the second experiment the distance between two knobs of an induction coil at the setting when a spark just passes through were determined by Vernier callipers. Table 2 gives the observations of one of my students.

TABLE 2

Spark length L at various primary voltages of an induction coil

12 VOLTS		11 25 VOLTS		10 5 VOLTS		10 VOLTS	
L in cm	*Mean L in cm*	*L in cm*	*Mean L in cm*	*L in cm*	*Mean L in cm*	*L in cm*	*Mean L in cm*
		5.08		4.83			
6 39		4 98		4.85		4 32	
6.29	6 34	5.07	5.05	4.95	4.91	4 38	4.33
6.27		5.09		4.97		4 29	

There can be many other similar experiments. Some of these are:

1. Measuring the depth of focus—focus on a spot, say, 10 times the objective of a vertically travelling microscope.
2. Measuring the resolving power of a telescope.
3. Measuring the length of a small rod by a metre scale.

It is necessary at this stage to consider the oft repeated question: "Can we read the fraction of a least count?" In laboratories some people dismiss this question outright, but the majority favour reading up to half of the smallest interval. It is unconvincing that the eye cannot judge better than half the minimum spacing between two consecutive divisions. A more realistic attitude would depend upon how big the scale division is and how fine are its markings. The author is definitely of the view that in favourable cases like measurements by a metre scale, the eye can estimate one decimal place higher than the least count. The last experiment mentioned above becomes useful if the ends of the rod are put between two marks on the scale and the readings are estimated to 1/10th of a millimetre. For each observation the ends are slightly shifted from the previous position.

A few experiments on the measurement of mass and time are suggested below:

Measurement of mass:

Measure a small mass five times by the method of oscillations.

Try to read 1/10th of a division by a spring balance. Do it five times.

Note 25 times the period of swing of a pendulum to 1/10th of a second.

Measurement of time:

To increase the value of these experiments, the students may now be asked to plot the data in Table 1, as follows:

a. reading obtained against sequence of measurement
b. mean of the first readings against number of readings, i.e., mean of the first two against 2, mean of the first three against 3, etc.
c. a histogram, i.e., the number of occurrences of a reading within a small interval against the chosen interval (steps).

The above graphs will indicate that as the number of readings is increased

in (b) the mean tends to assume more or less a constant value. In (c) a smooth curve (frequency distribution) is obtained by joining the mid-points of the verticals and the steps, such that the area under the curve is equal to the area under the histogram. For a very large number of readings the curve should approach a 'normal frequency distribution', or Gauss's 'normal error curve'. The maximum of the distribution curve gives the 'mean' or the 'most probable value'.

A word of warning is necessary here: not all quantities obey the Gaussian distribution law. For example, if the radius of a lead shot obeys the Gaussian law, its volume will not. In fact, there are more cases of departure from the normal curve, than otherwise, and therefore it is better to test before applying it However, for small errors of the type met with in physical experiments, the Gaussian law is a fairly good approximation and is mathematically convenient. A non-Gaussian distribution is the Poisson distribution. It gives the frequency distribution, among equal time intervals, of events which occur at random in time, e.g., in counting experiments in nuclear physics and other fields. Further, it can be shown that the Gaussian and Poisson distributions are special cases of the more general binomial distribution. This turns out to be so because the binomial coefficients are symmetric about the mean position.

The experiments and various plots described above illustrate only one point. ideals are absolute, they are unattainable. A value 4.5 cm is not 4.5000 .. , but is uncertain by some amount; this uncertainty can be determined by statistical analysis. So, it is better to talk of *tolerances*. In spite of uncertainties quite a lot of useful work can be done. These uncertainties should not discourage us from experimenting. It is also worth while to point out that the accuracy obtained in the above series of measurements depends upon the reliability of the standards of length, mass and time used (mostly they are the secondary standards); for example, weights may err by a few milligrams; the temperature on a thermometer may be off the true temperature by $+2^\circ$, the resistances of the standard resistance boxes are within 10 per cent of the figures written on them. These tolerance limits can be had from the manufacturer or obtained by comparison with some fixed standards.

An objection commonly put forward is that students are immature and would use the tolerance factors as an excuse and blame instruments for their own unsatisfactory performance. To this author, however, ignorance is never bliss; students should be asked to be careful from the very beginning for it takes quite some time to give up a bad habit. Deliberate mischief is much better than an error committed out of ignorance. Students sometimes complain. "Why are we asked to work with bad instruments?" The answer to this is. "We are trying to train you in an intelligent use of the instruments, i.e., how to arrive at the best from the worst." Apart from the fact that no instrument is perfect, one may come across many situations in practical life where a rough estimate is to be made from crude measurements. These estimates also afford a valuable check on

accurate measurements. In the absence of a tape, for example, the dimensions of a hall may be found by using the hand.

Observations to be Rejected

Sometimes, in an experiment of the type cited in Table 1, one reading may be wide off the mark, i.e., it may be very much different from the arithmetical mean. This reading may be rejected if it is a clear-cut case of misreading a scale due to some preoccupation or accidental movement of the instrument or a mistake in recording. The only test for the nature of such 'wild' readings is that even a large number of repetitions will fail to reproduce them. A pencil of 10 cm length cannot all of a sudden become 11 or 20 cm. Apart from this, there is no magic formula to suggest the rejection of an observation.

The statement, based on statistical analysis, that readings differing by more than five times the mean value may be discarded, should be applied cautiously. Such chance readings are by no means ruled out. They lie on the tail of the Gaussin curve; the only thing is that the probability of such happenings is less than one per cent. There is no justification in taking three readings and out of these rejecting the third on the basis of the above criterion; a correct decision can only be made if the number of readings is sufficiently large, say a hundred.

In the absence of absolutely certain evidence, 'wild' readings should be retained. Such readings have been responsible for many important discoveries. To cite a few example, the discrepancy between the density of nitrogen prepared from air and that of a sample produced chemically led to the discovery of argon by Lord Rayleigh. Again, extra signals in radio receivers have been attributed to messages from Mars.

Which Mean to Take

Having established that even under similar conditions observations show a scatter, a very vital decision still remains to be taken, i.e., which reading is most likely to be near the actual value and with what confidence it is to be taken. Here one uses the method of means. The mode, median and arithmetical mean are various forms of means or averages. The use of a particular type of mean depends upon the nature of the problem.

Mode (fashionable, common) is the most frequest or most popular value of a variable. In a frequency distribution curve, it corresponds to the peak value of the variable. For example, certain varieties of hats or prints may be in greater demand, accordingly, a shopkeeper can regulate his order by studying the 'mode'.

The median corresponds to a value of the variable such that half the observations are higher than it, and the other half are lower. It divides the frequency distribution curve into equal areas. The concept is useful for a comparison of two or more population=spread curves relating to one particular type of problem. For instance, one may wish to grade some Intermediate colleges in the order of their results in the U.P. Board Intermediate Examinations. If the number of students appearing from each institution is the same, then one way is to compare them according to

their modes, i.e., placing in order of the highest marks secured by the students. Is this a correct assessment? A little thinking would reveal that the institution in which more than half of the students have fared well is definitely superior to others, i.e., the median is a better way of grading. Similarly, the prosperity (per capita income) and yearly progress of a country with respect to others is judged better by the median than by the mode. Further, if variations in different groups are to be studied (for example, variations of income ranging between Rs. 60-80 p.m., Rs. 100-120 p.m., or improvement in weak and mediocre students, etc) then the curves are divided into parts and their corresponding medians studied. Such medians are called quartiles, sextiles, etc., according as the curve is divided into four or six parts.

Arithmetical Mean

This is the quotient obtained by dividing the sum of weight observations by their total number. The arithmetical mean

$$w = \frac{w_1 n_1 + w_2 n_2 + \ldots + w_m n_m}{n_1 + n_2 + \ldots + n_m}$$

where w_1, w_2,. . are the readings, and n_1, n_2, ...their statistical weights, i e , the number of times the readings have been obtained

The mode, median and arithmetical mean are different for a skew distribution and merge into each other for an asymmetric or skew distribution.

For numerical work the arithmetical mean is mostly used. It has the following properties.

1. The average is influenced by all portions (high, medium, low) of the curve.
2. Errors of measurement tend to neutralize one another around the arithmetical mean; the error of this average is much less than the error of a single measurement.
3. It is better suited for statistical calculations like working out standard deviations and correlations coefficients.
4. When multiplied by the total number of observations, it yields the total value.
5. It is more reliable than the median or mode, i.e., it will fluctuate less widely than either of the two.

There are three difficulties as regards a general use of mode or median: (i) they can be obtained only from curves and their positions depend on the manner in which the intervals are divided and plotted; (ii) they cannot be exactly determined by mathematical analysis; and (iii) unlike the arithmetical mean, they cannot be used for obtaining totals.

A beautiful example of the use of the mode and the arithmetical mean is provided by the velocity spectrum of the molecules in a gas or a liquid. The problem may be to know the position of maximum intensity of a spectral line, whether or not the molecules will overcome the gravitational pull of a planet or evaporate from a liquid, or a study of transport properties; we accordingly use mode, tail of the curve or arithmetical mean respectively. However, in physics, we need only one value, the most probable or the modal value. In periodic stress measurements

it may correspond to the breaking point. In this respect, the median is of little use

For other types of means like the geometric mean, the harmonic mean, etc., the reader may refer to standard texts on the subject.

How to Take the Mean

(a) *Mean of means.* In certain types of experiments like Young's modulus, modulus of rigidity of a wire, Ohm's law, etc, one often takes the mean of means. The purpose of adopting this special procedure is to see that in each large interval, the elongation or twist produced per unit load is uniform This also smooths out the variations observed in very small intervals which may be superficial. The rule adopted in taking the mean of the means is that the readings be so arranged that in the final mean no reading is eliminated. It has been observed that this rule is often violated and this has prompted the author to bring it to the reader's notice. An example is given below in Table 3. The mistake may be inadvertent but think of the harm it does to beginners.

In the above method, readings 4, 5, 6, 7 which are taken twice do not enter into the final average. The correct procedure would be to find the mean twist for 1.2 kg between the readings 0-6, 1-7, 4-10.

(b) *Mean of quantity occuring in the first power, second power or higher powers.* One should not blindly take the average of the quantity measured. It must be decided by the purpose for which it is needed.

Quantities Occurring in the First Power

In kinetic theory, in all transport phenomena, the mean velocity of a molecule is used and not the root mean square. If the problem is to find the radius of a single lead shot, it may be determined a number of times and averaged out.

TABLE 3

The wrong method of taking means in modulus of rigidity by the statical method

S. No.	Load in kg.	Mean twist in degrees	Mean twist in degrees for 0.6 kg.
0	0	0	
1	200	2	
2	400	3	4 5
3	600	4 5	4.0
4	800	6	4.5
5	1000	7.5	4.5
6	1200	9	4.0
7	1400	10	4.0
8	1600	11.5	4 0
9	1800	13	4.5
10	2000	14.5	

Mean twist per 0.6 kg.=4 0

Synthetic High Molecular Substances : II

V. A. GLUSHENKOV
C. RADHAKRISHNAN

TODAY the production of polymers is very important not only in everyday life but in industry also. A few polymers are therefore discussed below.

1. Polyethylene

Polyethylene is obtained these days by the following methods depending on pressure:

a. *The method of high pressure.* In this method polyethylene is obtained under a pressure of 1200–1500 atmospheres and a temperature of 200–250°C. Atmospheric oxygen acts as initiator in this reaction of polymerization. Peroxide compounds are obtained by the interaction of ethylene with oxygen, which produce radicals on decomposition. The reaction of polymerization takes place with the help of such radicals. Polyethylene of high pressure has an average molecular weight of 25,000 to 50,000 oxygen units. High temperature, pressure and partial oxidation of ethylene during initiation of this reaction of polymerization, produce an irregular structure of molecule. For example for every 100 CH_2 groups there are on an average 3 side chains:

$$\cdots CH_2 - \underset{\displaystyle CH_3}{CH} - CH_2 - \cdots$$

High pressure polyethylene is a solid having a yellow-white colour like horn, with a specific gravity of 0.92–0.95 and a m.p. of 100–110°C. It has pretty good dielectric properties and does not react with most of the chemical reagents. Water and gases do not pass through a polyethylene film. But in air polyethylene suffers oxidation and after some time its physical and chemical properties deteriorate. To prevent this phenomenon, some aromatic diamines, phenols, etc., may be added; these slow down the process of oxidation.

b *The method of low pressure (Ziegler's method).* At atmospheric pressure ethylene polymerizes in the presence of com-

plex Ziegler catalysts (triethyl aluminium, tetrachloro-titanium). The reaction takes place by a mechanism of anionic polymerization. Triethyl aluminium is spontaneously inflammable in air. Hence this reaction is conducted in an inert and dry solvent in an atmosphere of nitrogen. The reaction is started at room temperature. The temperature is gradually raised to 70°C. The Ziegler method is important because with the help of this method it is possible to regulate the average molecular weight of the polymer by changing the correlation of the composition of the catalyst $Al(C_2H_5)_3$ and co-catalyst $TiCl_4$ and by addition of other alkyl metals. For example, with equimolecular correlation of $Al(C_2H_5)_3$ and $TiCl_4$ the average molecular weight of polythylene will be between 60,000 to 100,000 and m.p., 125–130°C. Its carbon chain has almost no branch. Hence the degree of packing of the molecules is rather high and it is more crystalline than polyethylene of high pressure. But polyethylene of low pressure gets spoiled on storing because of the remains of catalyst and solvents present in it.

c *The method of average pressure.* Polyethylene of average pressure is obtained in the presence of the catalyst—the oxide of metals of variable valency (chromium oxide of aluminium silicate). The reaction takes place by the mechanism of anionic polymerization at 130°C and 30–35 atmospheres pressure in the solvent xylene of toluene. Polyethylene of average pressure is characterized by the presence of a linear structure. It is possible to regulate its molecular weight by changing the temperature of the reaction of polymerization. Thus at 110°C the average molecular weight of the polyethylene obtained is 100,000 but at 170°C the average molecular weight is only 25,000. Nowadays it is very difficult to select and use only one of the above-mentioned methods of polymerization, because polyethylenes obtained by different methods have different properties.

Polymers of Substituted Ethylenes

Substitution of the hydrogen atoms in ethylene by atoms or groups of atoms which have a greater affinity for the electron than the carbon atom has (i.e., they are electrophilic) causes the polarization of the molecule and the activation of the double bond. As a result, substituted ethylenes polymerize more easily than ethylene itself. For the synthesis of polymers, the following are very important:

$CH_2{=}CH{-}Cl$ Vinyl Chloride	$CH_2{=}CCl_2$ Vinylidene Chloride	$CF_2{=}CF_2$ Tetrafluoroethylene	$CH_2{=}CH{-}O{-}R$ Vinyl ether
$CH_2{=}CH.O.CO.CH_3$ Vinyl acetate		$CH_2{=}CH.COOR$ Substituted acrylic acid	$CH_2{=}CH{-}C_6H_5$ Styrene

Poly (vinylchloride) (PVC)

This is obtained by the polymerization of vinyl chloride in the presence of a peroxide initiator.

$$n\,CH_2{=}\underset{\underset{Cl}{|}}{CH} \rightarrow \left[-CH_2-\underset{\underset{Cl}{|}}{CH}-\right]_n + Q$$

PVC is a white amorphous powder with a specific gravity of 1.4. It is possible to make PVC by pressing, stamping, moulding and other methods. It has a good deal of mechanical strength and is used for making tubes, for lining electrolysis baths, for making reservoirs for acids, alkalies, etc. It is possible to manufacture artificial preventive fabrics from it (with the addition of plasticisers), artificial leather shoes, raincoats, etc.

Polytetrafluoroethylene (Teflon)

Teflon is obtained by the polymerization of tetrafluoroethylene in the presence of a peroxide initiator.

$$n\,CF_2{=}CF_2 \rightarrow \left[-CF_2-CF_2-\right]_n$$

Teflon has very good stability to heat and cold. It remains solid even on heating up to 250–300°C but at temperatures above 600°C depolymerization starts. This causes difficulty during manipulation with pressure moulding and stamping. Its chemical inertness, toughness, self-lubricating properties and good electrical resistance make teflon an excellent material for electrical insulation, chemically resistant gaskets, valves, diaphragms and other machine parts. Teflon finds use also in rocket and aeroplane construction. This is a substance that will be much used in the future.

Poly(methylmethacrylate) — (Plexiglass)

Poly(methylmethacrylate) is obtained by the polymerization of methylmethacrylate in the presence of a peroxide initiator.

$$n\,CH_2{=}\overset{\overset{CH_3}{|}}{\underset{\underset{COOCH_3}{|}}{C}} \longrightarrow \left[-CH_2-\overset{\overset{CH_3}{|}}{\underset{\underset{COOCH_3}{|}}{C}}-\right]_n$$

Poly(methylmethacrylate) is well known as organic glass. In some of its properties, it is much better than silicon glass. Thus organic glass allows the passage of ultra-violet rays of light but silicon glass does not. Furthermore, it does not break into splinters and it is lighter than glass (specific gravity 1.2). Also known as aviation glass, it finds very wide use in the aviation, electrical and radio industries and in the manufacture of household utensils.

Polystyrene

$$n\,CH_2{=}\underset{\underset{C_6H_5}{|}}{CH} \longrightarrow \left[-CH_2-\underset{\underset{C_6H_5}{|}}{CH}-\right]_n + Q$$

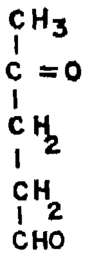
Polystyrene is a transparent glass from which it is possible to manufacture articles by mechanical methods (pressure moulding, etc.). At a temperature above 100°C polystyrene starts softening and after 150°C, it can be pressed, i.e., it can be moulded into any shape by hand. Polystyrene has very good dielectric properties and hence it is used in the electrical

and radio industries and for the production of household utensils.

RUBBER

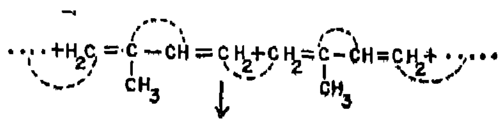
The Structure of Rubber

Chemical investigations have shown that rubber is a hydrocarbon with a high molecular weight. On distillation, natural rubber decomposes with the evolution of isoprene. On the basis of this discovery it was assumed that rubber is a product of the polymerization of isoprene—poly. isoprene—with the empirical formula $(C_5H_8)_n$. The *unsaturated character of rubber was shown by its reaction with bromine* when bromine was added to it, giving a white insoluble product $(C_5H_8Br_2)_n$. Especially important in this connection is the reaction of rubber with ozone. The ozonide $(C_5H_8O_3)_n$ obtained, on hydrolysing with water gives laevulinic aldehyde.

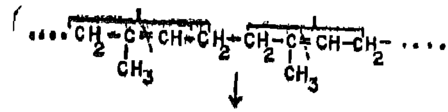


By the keto and aldehydic groups of laevulinic aldehyde it is possible to determine the position of the double bonds in the unsaturated hydrocarbon, rubber. In 1922, on the basis of all the above-mentioned evidence, H. Staudinger put forward a hypothesis which is now accepted. According to this hypothesis, natural rubber is an unsaturated acyclic hydrocarbon built up of isoprene units which are combined to form long chains of carbon atoms The average molecular weight of rubber was shown to be 100,000–150,000 O.U.

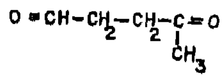
The Scheme of Formation of the Chain



Isoprene
2—methyl, butadiene—1, 3



Ozonization and decomposition of ozonide



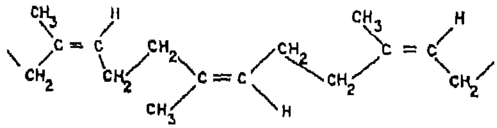
Laevulinic aldehyde

Configuration of the Macromolecular Chain

After mechanical stretching of rubber, with the help of X-rays it has been shown that rubber has a crystalline (orderly) structure, i.e., the macromolecules are oriented parallel to one another. In the unstretched condition rubber has both crystalline and amorphous parts existing together. Due to the large size of the molecules the macromolecules could orient themselves in such a manner that at one place they are parallel and at another place they are not.* Almost all the olefine

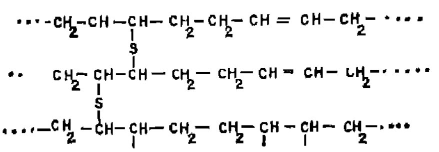
* See V. A. Glushenkov and C. Radhakrishnan, "Synthetic High Molecular Substances· I", **School Science,** June 1967, V:2, 103-112.

chains of rubber have a cis-configuration:



Vulcanization of Rubber

When rubber is treated with sulphur or sulphur monochloride (S_2Cl_2) with the addition of a promoter for the reaction, it turns into an elastic mass which is termed vulcanized rubber. This reaction was discovered by Charles Goodyear in 1839 and is well known as the process of vulcanization. Perhaps it is a process of formation of 'bridge bonds' between different chains of molecules. The linear structure of the molecules of rubber is thus turned into a 'net' structure by vulcanization. This process prevents the sliding of chains during stretching and improves the elastic property of rubber.



The vulcanized soft rubber contains one to five per cent of sulphur by weight. For saturation of all the double bonds of the molecules of polyisoprene it is necessary to put in about 32 per cent of sulphur by weight. The polymer obtained has a three-dimensional structure and is called ebonite. Ebonite is characterized by the absence of elastic properties, and poor stability at low temperatures (it breaks after 0°C) and high hardness and good dielectric properties. Ebonite is widely used in the electrical industry.

The development of industry today is impossible without a highly developed rubber industry. The world rubber industry now uses more than four million tons of rubber, of which more than two million tons is synthetic rubber.

Synthetic Rubber

In 1928, the Russian scientist, G. V. Lebedev, discovered the conditions under which ethyl alcohol could be converted in a single stage into butadiene with a good yield.

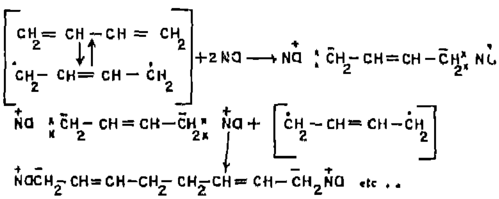
$$2CH_3-CH_2-OH \xrightarrow[Al_2O_3,\,ZnO]{400^\circ C} CH_2=CH-CH=CH_2+2H_2O+H_2+Q$$

Lebedev's method for preparation of butadiene from alcohol and its conversion into rubber suitable for vulcanization was adopted for industrial exploitation, and the first plant for producing synthetic rubber was built in 1932 in the Soviet Union. The discovery of the industrial method for preparation of synthetic rubber is a scientific achievement of a high order. In Germany the production of synthetic rubber started in 1937 and in the U.S.A. in 1942. But Lebedev's method for the preparation of synthetic rubber is now being replaced by Bezov's method (the production of monomers as a bye-product of the oil industry). But the first method could be profitable for some time more provided ethyl alcohol is obtained from inedible raw materials.

Nowadays many kinds of synthetic rubber are available and some of them have better properties than natural rubber.

Some Important Synthetic Rubbers

1. *Sodium—Butadiene Rubber.* Synthetic sodium—butadiene rubber was first produced in 1932 by Lebedev's method. Sodium was used as a catalyst in this process. Sodium perhaps produced an ionic compound with butadiene. This ionic compound could attract a large number of molecules of butadiene not only in 1, 4 positions, but also in 1, 2 positions:



The structure of polymers of butadiene is more complex because they contain side-chains. Sodium butadiene rubber is available for common use. It is used in vulcanized form for production of different kinds of goods such as toys, household articles, etc. It also finds wide use in industry Nowadays many modifications of this type of rubber like Buna-S and Buna-N are available but all of them get swollen in petrol and kerosene.

2. *Chloroprene Rubber*

$$\left(-CH_2-CH=\underset{\underset{Cl}{|}}{C}-CH_2-\right)_n$$

Choroprene—

$$\left(CH_2=CH-\underset{\underset{Cl}{|}}{C}=CH_2\right)$$

itself has the ability to polymerize very easily. Even at room temperature it is possible to observe the polymerization of chloroprene with the oxygen of air as initiator. For ten days the process goes on through the formation of linear polymers, leading to the formation of three-dimensional structures.

Polychloroprene is however prepared by the polymerization of chloroprene in the presence of potassium persulphate as an initiator. In the U.S.S.R. chloroprene rubber is manufactured under the name of 'naeiet' and in the U S.A. as 'neoprene'.

This rubber is characterized by a good deal of mechanical strength, non-inflamability and resistance to the action of liquid combustible oils (mineral oils). It is used for the manufacture of conveyor belts, cable covers and rubber tubes for the transportation of oil products, and in automobile and aeroplane parts and other industrial machinery However, vulcanized polychloroprene is not so good as natural rubber in its elastic properties and stability to cold.

3. *Isoprene Rubber (Polyisoprene)*

$$\left(-CH_2-CH=\underset{\underset{CH_3}{|}}{C}-CH_2-\right)_n$$

Polymerization of isoprene takes place in solution in the presence of metal organic compounds of lithium, aluminium and other metals (substances similar to Ziegler's catalyst). The use of such a catalyst has helped in the synthesis of a stereo-regular molecule of the polymer with a cis-configration. The industrial method for the synthesis of stereo-regular polyisoprene was made

possible by the work of A. A. Korotkov.

Stereo-regular polyisoprene is quite like natural rubber. It has a good deal of mechanical strength and elasticity. This rubber is used in the manufacture of tyres for heavy duty vehicles, and high speed automobiles and aircraft.

4. *Butyl Rubber*. Butyl rubber is a co-polymer of isobutylene with a small quantity (up to 5 per cent) of isoprene. This mixture is polymerized at 100°C in the presence of catalysts, usually aluminium chloride. The addition of isoprene gives a polymer possessing units with double bonds. Therefore such a polymer could be vulcanized with a loose-knit net structure. This rubber combines elasticity with stability to cold and resistance to the action of corrosive liquids. Owing to its impermeability to gases, it is an excellent material for the manufacture of tubes for automobile tyres. Because of its very important properties and its simple method of production, butyl rubber is bound to find increasingly greater use in future.

The foregoing is a short account of some synthetic high molecular substances which are becoming more and more important in our lives, besides playing an increasingly significant role in the national economy of every country in the world.

The Rhythm of Light and Life

BERTHA BAGGERMAN

FROM the very beginning of its existence the earth has rotated on its axis once a day and has described an orbit around the sun once a year. As a result, conditions on earth change from day to day and from month to month as the seasons proceed through their annual cycle. Whatever conflicting views there may be about the origin of life on earth, it is unanimously held that there was light and an alternation of light and darkness before life was born. This life had therefore to adjust from its very beginning to the alternation of light and darkness and to the seasonal changes of lengthening and shortening days.

Until the twentieth century it was believed that fluctuations in temperature or the intensity of light or rainfall were responsible for all biological happenings connected with the changing of the seasons. Not until about 1900 was it discovered that the cyclical changes in the length of day, at least in the higher latitudes, are of much greater importance in this respect than those of temperature, light intensity or rainfall.

Living organisms have adapted themselves in dual fashion to the rhythms of light and darkness on earth. In the first place they can react to the seasonal changes of longer and shorter days, and in the second place they display reactions to the daily alternation of light and darkness. I should like to consider both kinds of reactions here. These reactions occur among plants and animals, I shall confine myself exclusively to the latter. It is precisely because botanists and zoologists cooperate so closely in this field that this aspect of research is developing and widening at such a rate. I shall discuss the influence of the length of day only with regard to those animals that spend at least a part of their lives in the temperate and polar regions of the earth; in this respect the reactions of animals to the climatic conditions of the tropics form a problem apart. For the same reasons, a discussion of the periodicity connected with the phases of the moon and with the tides will also have to be omitted.

First of all let us discuss the reactions of animals to the change of the seasons.

From *Higher Education and Research in Netherlands*, 1965, 9:3

Many kinds of animals, including a large number of birds and fishes, migrate to a given region where food is available and the temperature favours rearing of the young. In the case of most species, the adult animals and the young then leave to spend the rest of the year in another region where the conditions of life are more favourable during that period than in the breeding area. The following year they migrate again to the breeding area, and history repeats itself. It is therefore of the greatest importance for the survival not only of these migratory species, but also for that of other species practising seasonal reproduction, that they react in good time to the changing seasons. In fact, the situation even appears to be that the migratory animals, as it were, anticipate this change: they leave the breeding area even before the unfavourable season has really begun.

The first question that may be asked is: What factors from the outside world are responsible for the occurrence of migration and reproduction? As instances I should like to discuss very briefly the research done into this on an American migratory bird, the junco (*Junco hiemalis*), and a migratory fish, the three-spined stickleback (*Casterosteus aculeatus*). It was found that before these animals start to migrate they undergo a certain internal physiological change; once this has happened, the disposition to migrate is said to have been induced. It is supposed that the animals have now become susceptible to all kinds of external (and perhaps also internal) stimuli which initiate the migratory behaviour proper. The results of the experiments with the junco and the three-spined stickleback may be summarized by saying that in both the disposition to migrate is induced by the lengthening days in the spring. This condition was not achieved if the length of day was kept artificially short from a certain time in autumn onwards. The reproductive behaviour following migration also proved not to occur during these short days, though it did when the animals were exposed to a relatively long day, and the longer the day, the sooner the reproductive condition was reached. It was also possible to demonstrate that the end of the reproductive season and the ensuing induction of the disposition to migrate are in turn highly dependent on the length of day and that, moreover, an autonomous internal factor plays a part in this. In this respect temperature is of much less importance for both animals; it has been experimentally shown that, once the length of day has started off the processes, temperature can only accelerate or retard them, but cannot induce them itself.

I should like to point out that, when I speak in this context of lengthening or shortening days, I do not mean that it is this increase or decrease as such which is important, but the longer or shorter total hours of daylight; it has been possible to establish this experimentally.

Besides the junco and the three-spined stickleback, there are many other species of animals, both vertebrate and invertebrate, which have synchronized their ways of life with the changes in the length of the day and have in this way ensured their continued existence. I should like to mention a few examples. Like birds and fishes, mammals in temperate and polar re-

gions also have their reproductive season confined to a certain time of the year In mammals, which mate and produce their young in the spring, this behaviour is likewise found to be caused by the lengthening days. But there are also a number of species which mate in autumn, such as deer, and the mating behaviour of these animals also proves to be induced by the length of day, though in this case by the shortening days of autumn. Viewed functionally, this is for these animals the most suitable time of the year to display mating behaviour, since the period of gestation is very long (eight months) and in this way they can give birth to the young in the climatically favourable spring.

However, animals make use of the changing length of day not only for the occurrence at the right time of migratory and reproductive behaviour, but also for maintaining all kinds of other adjustments. For instance, short days in the autumn cause the thick winter coat of mammals to grow, which is then replaced by the summer coat the next spring as a result of the day's lengthening. Adjustments to the length of day also occur among many lower species of animals, including insects. The short days of autumn, sometimes in collaboration with the temperature, induce in many of them a kind of hibernation (called 'diapause'), in which they spend the unfavourable season. This diapause is again terminated in the spring by the increasing hours of daylight, likewise in collaboration with the temperature in some cases.

All these examples make it quite clear that an important part is played by photo-periodism in the life of most animals. Their survival is based entirely on their reacting correctly and in good time to changes in the length of days as the seasons elapse. From the functional point of view it is obvious why such a marked adjustment has developed to the length of day and not, for instance, to temperature or rainfall. For, in the temperate and polar regions there is absolutely no other factor which goes through the same cycle with such regularity and without any variation from year to year.

The following question must be answered. What really goes on in the animal itself when it is exposed to a certain length of day? By way of example I shall discuss the research that has been done on this subject with regard to reproduction among birds. It has been possible to demonstrate that in the reception of light stimuli there is close collaboration between the central nervous system and the endocrine system (composed of glands secreting hormones), whilst specialized nerve cells, known as neuro-secretory cells, form the link between these two systems. By various paths through the brain the light stimuli reach the hypothalamus, a very important part of the brain. Here are located the neuro-secretory cells which, under the influence of that stimulus, proceed to produce a lesser or greater quantity of a substance called neuro-secretion, which affects the hormone-producing activity of the hypophysis. The hypophysis is a highly important gland which lies immediately under the hypothalamus and in its turn can regulate by means of hormones the hormone-secreting activity of a large number of other glands, including the sex glands, the thyroid gland and the

cortex of the adrenal glands. Finally, reproductive behaviour proves to occur when there is a high level of sex hormones in the blood.

To sum up, it may be said that a long day influences reproductive behaviour through stimulation of the hypothalamus-hypophysis system, which in its turn stimulates the sex glands to produce larger quantities of sex hormones, while the latter are ultimately responsible for the occurrence of reproductive behaviour.

The hypothalamus-hypophysis system also plays an important part in inducing the migration disposition in birds and fishes, although we are less informed about the hormones which are involved; in the case of the three-spined stickleback it has been shown that in particular the hormones of the thyroid gland play an important role. In invertebrate animals, which are of quite a different anatomical structure, we can still see a striking similarity to vertebrates as regards reactions to the length of day. here, too, neuro-secretory cells form the link between the nervous system that conducts the light stimuli and hormone-secreting glands which influence behaviour.

Thus, although we nowadays have some idea of how the stimuli of light and darkness may influence behaviour, the picture which it has been possible to form of a number of the links involved is still very imperfect. For instance, we do not yet know how the stimulation proceeding from periods of light or darkness can enhance or inhibit the activity of the neuro-secretory cells in the hypothalamus, nor do we have a proper understanding of the nature of neuro-secretion and the way in which this can affect the hypophysis. Furthermore, we have been able to obtain only a superficial picture of the manner in which hormones can affect behaviour.

Finally, it might be asked how animals are capable of reacting by different forms of behaviour to a short and a long day. In general, one speaks in this connection of the exceeding of a more or less clearly delineated critical length of day, as a result of which certain processes are stimulated or inhibited. It is, however, strange that until recently nothing definite had really ever been said about the way in which the animal determines whether this critical length of day has been exceeded or not. But in recent years a small number of scientists have postulated that the basis of the mechanism with which a distinction is made between long and short days ought to be sought in the 'biological clock' that forms the foundation of a daily periodicity in sensitivity to light.

For the moment I cannot discuss this, because for a proper understanding of it one first should know something about the reactions of animals to the daily periodicity of light and darkness.

As we all know, animals have adjusted to the daily rhythm of light and dark, and we speak of nocturnal, diurnal and crepuscular animals, depending on whether they are most active at night, by day or in the twilight. The following example may serve further to illustrate this adjustment to the daily rhythm of light and dark.

The white-footed mouse (*Peromyscus leucopus*) is a typical nocturnal animal, because every day it becomes active about half an hour after dark. Towards morning its activity gradually declines

and for the rest of the day it is inactive until darkness falls again. Irrespective of whether it is exposed to twelve hours of light followed by twelve hours of darkness, or, for instance, to eight hours of light and sixteen hours of darkness, or *vice versa*, it always proves to become active about 30 minutes after the light has gone. It might be concluded from this that the light/dark stimulus is the only factor that determines when the animal is to become active. But further research has shown that this is much too simple a picture. Tests in which the animal was exposed to continuous light or continuous darkness at constant temperature illustrated this: even under these most exceptional conditions there proved to be an activity rhythm of about 24 hours between the moments at which the animal became active, whilst in continuous darkness this period was somewhat shorter than 24 hours. This therefore shows that the rhythmical behaviour must be caused by something inside the mouse. For under these conditions the external light/dark stimulus was absent. The fact that the rhythm has a period that deviates from 24 hours at the same time proves that the animal did not react to other possible external factors which were not kept constant, as for instance ionizing and cosmic rays or electromagnetic fields, which have a periodicity of exactly 24 hours because they are connected with the earth's rotation.

We must therefore assume that the rhythm of the activity has an internal cause. Such a rhythm that is caused endogenously and has a periodicity differing from 24 hours is called a circadian rhythm, from 'circa' and 'dies'.

Besides this rhythm in activity we also know of some fifty other processes in the mouse which likewise display a daily periodicity. I shall mention a few of them. Body temperature is at its highest about midnight and at its lowest around noon. The maxima and minima of this rhythm thus coincide with those of the activity (they are caused by it), and these two rhythms are said to be in phase. The number of eosinophilic cells in the blood (these are a kind of white corpuscle) displays a rhythm with an opposite phase: the highest (or lowest) number of eosinophiles occurs precisely at the time when the activity and temperature are at their lowest (or highest). A further important point is that under normal conditions these phase interrelationships are strictly maintained.

Now where must we seek the cause of these rhythms? It has been possible to demonstrate experimentally that the three rhythms mentioned are dependent on a fourth rhythm that must be sought in the adrenal cortex: if the adrenal glands are surgically removed these rhythms disappear entirely. I have already mentioned in passing that the hormone-secreting activity of the adrenal cortex is regulated by the hypothalamus-hypophysis system. Now when this latter system is put out of action surgically in a normal animal, the above rhythms continue to occur, though to a lesser extent. On the basis of this and other tests it is now assumed that the cause of these rhythms must be sought in an endogenous circadian rhythm in the secretion of cortical hormones, the hypothalamus-hypophysis system being responsible for synchronization with the daily light/dark stimulus.

Although the hormones of the adrenal

cortex play a major role in the regulation of very many life processes, there are nevertheless no indications that all the rhythms occurring in the mouse originate in this organ. But the example clearly shows how complicated these matters are and how it must be constantly realized that cause and effect are often difficult to distinguish from one another.

The stimulus of the transition from light to darkness or *vice versa* proves in nature to be the principal synchronizing factor in most animals. However, in the absence of this stimulus, or in cases in which this offers functional advantages for an animal, other external factors may act as synchronizers. Chief among these is a periodical rise or fall of temperature.

We can now go into the matter of how it can be that internal rhythms occur which work with the precision of a clock. What enables an organism to measure time, and how must one conceive of such a biological clock?

Though a particularly large amount of research is being done on this subject, we have really got not much further than a definition of the properties of such clocks and the devising of mathematical and physical models according to which such mechanisms could work. It is supposed that biological clocks must be sought at cellular level and that they are based on biochemical and/or biophysical processes. Of the biochemical processes that might play a part, I shall mention only the synthesis of ribonucleic acids, and of the biophysical processes, those connected with the transmission of energy (as in the mitochondria, among others).

A very striking property of biological clocks is the fact that, within the limits of some tens of degrees, they are practically insensitive to changes in temperature. This property makes it hard for many scientists to understand how in that case those clocks could be based on biochemical processes, which are known to be highly sensitive to changes in temperature in most cases. A number of them therefore believe that the cause must be sought rather in biophysical processes, which after all do possess the property of being practically immune to fluctuations in temperature.

However difficult it may be to explain this insensitivity of the clocks to the influences of temperature, it is clear that this property is of the greatest importance to the organism. For, if the clocks were susceptible to fluctuations in temperature, they would soon be running fast or slow in respect of sun time and then nothing would come of the special adaptations which the animals display to the rhythm of night and day. As an instance of such an adaptation we have already mentioned that animals are active either by day or by night or in the twilight; their whole way of life is adapted to this. The biological clock also plays a very important part in the orientation of birds, fishes and insects. When these animals move about (for instance, birds and fish migrating to or from their breeding area; bees flying to and from the hive) they must be able to orient themselves to find the way. Most species do so with the aid of the sun's position. But since the sun constantly changes position in the course of the day, a correction has to be applied for this in orientation. These animals apply this correction by means of a biological clock, which tells them what

the exact time is and what correction they have to make to their direction of flight, etc., to find or stay on the right course.

I should now like to consider for a moment what major effects the occurrence of many kinds of rhythmical processes in all organisms, from unicellular ones up to and including man, has on those organisms. As a result of these rhythms animals prove not to be equally sensitive to external stimuli at every moment of the day or night. To cite a striking example: when mice were exposed in the evening at 9 p.m. to a certain dose of X-ray irradiation, the result was that these animals died within two weeks. But when other mice received exactly the same dose twelve hours later (that is to say, at 9 a.m.) they did not suffer the slightest injurious effect. The same applies to the administering of bacterial endotoxins: depending on the moment of the day at which a certain dose is administered, it will be either fatal or practically harmless. Repetition of this kind of test always gives the same result; these findings cannot therefore be based on chance but are caused by a daily periodicity in the sensitivity of the organism. For instance, a daily periodicity has also been demonstrated in susceptibility to doses of hormones (such as growth hormone, gonadotropic hormones, insulin), to carcinogenic substances and, in the case of man, to barbiturates and to the psychotherapeuticum librium.

It has further been found that animals also display a daily periodicity in their sensitivity to light. This is a property which might be of the greatest importance because, as I have already mentioned, it may form the basis of the seasonal periodicity. The trend of this light-sensitive process might be imagined to be as follows. It is initiated by the transition from darkness to light at the beginning of the day. As a result the animal now becomes increasingly sensitive to the effect of light, until after a certain period of time a maximum is reached, whereupon the sensitivity gradually decreases until it becomes light again the next day. Once this process has got under way it continues, even if it becomes dark again after a shorter or longer time.

Now if, to give an example, the day is so short that the maximum sensitivity is not reached, the animal will react to this as to a short day. But if the day lasts so long that the optimum is attained, if in other words the duration of light exceeds the critical length of day, the animal will react to this as to a long day. This is the way in which the biological clock which regulates the daily sensitivity to light is envisaged as also being able to form the basis of the seasonal periodicity.

As stated, there is a fixed relation in time between the various processes taking place in an organism. Think of the relationship between activity, temperature and number of eosinophilic cells which we encountered in the white-footed mouse. The existence of these fixed interrelationships also has important consequences for an organism. Interruption of these relationships may have more or less serious effects on the organism and in extreme cases may lead to the formation of malignant tumours. Even a fairly simple change in external conditions may disturb this relationship and cause desynchronization of the various rhythms. If, for ins-

tance, an organism is used to the fact that the light goes off every day at 6 p.m., and this situation is suddenly changed in such a way that the light from then on goes off six hours later, the organism proves to need two to four days to adjust to the new situation. It also emerged that one rhythm adjusts much more quickly than another, so that during this period of adjustment there is a desynchronization between the various rhythms. Now, when such manipulations were continued for a long time, so that the animals were in a constant state of desynchronization (as was done in experiments with cockroaches), these animals developed intestinal tumours which in extreme cases even became malignant. Such a desynchronization of rhythms can also occur under constant exposure to light or in continuous darkness (at constant temperature), since in the absence of a common external synchronizer every rhythm proceeds to display its own period, which may differ more or less strongly from 24 hours.

We may therefore conclude that for the well-being of an organism it is of the utmost importance that the various rhythms are maintained. I shall come back to this in a moment.

Finally, I should like to consider in somewhat greater detail the occurrence of rhythms in man and the consequences which this may have for him.

It has been demonstrated that in man, too, a large number of processes occur that display a daily periodicity. Such processes are to be found in all the important physiological systems, such as the circulation of the blood, respiration, digestion, excretion, and in the nervous and endocrine systems. A striking phenomenon is that practically no rhythms occur in new-born babies and that they do not develop simultaneously, but one after the other. To cite a few instances: in the second or third week after birth a rhythm develops in the quantity of urine excreted, although the rhythm in the excretion of sodium and potassium does not appear until after the second month. The rhythm of body temperature begins to manifest itself in the third week, whilst that of the heart-beat appears about the sixth week. A noteworthy feature is that the rhythms of heartbeat and sleep develop at a later stage after birth in premature babies than they do in normal ones, on the strength of which it is supposed that the time of occurrence of various rhythms depends not so much on a fixed period of exposure to a synchronizing environment as on a certain stage that must be reached in development.

Of great importance to what is to be discussed next is whether these rhythms are a result of man's habits of life, or whether they are of endogenous origin. We have seen from the tests on animals that the best way of investigating this is exposure to continuous light or to continuous darkness. It is, of course, difficult to perform such tests on men; nevertheless, valuable data have been obtained from the examination of persons staying temporarily or permanently in the polar regions, where there is continuous light in the summer and continuous darkness in the winter. Moreover, for a number of years observations have been performed on people who lived on Spitsbergen for six weeks in the summer under strictly supervised conditions. These people were

divided into two groups and their rhythm of activity and rest was determined by means of watches that were made to keep time 'wrongly'. One group had watches according to which the day lasted 27 hours instead of 24, the other group had a 21-hour day. All these investigations revealed that the rhythm of body temperature quickly adjusted to the new activity rhythms of 27 and 21 hours. So did the rhythm of the quantity of urine produced, but much more slowly; in the case of some people it took two or three weeks. However, the rhythm in the excretion of potassium did not adjust at all, but continued to display a period of about 24 hours; this is therefore a genuine endogenous circadian rhythm.

Other research indicates that there are still more processes in the human body with an endogenous rhythm as the basis. It may therefore be said that man's physiological system is subject to a periodicity of 24 hours, which has in part an endogenous origin, and has important consequences, especially for modern man.

The twentieth century, the century of growing industrialization, has seen the advent of shift work round the clock. Furthermore, an increasing number of industries use assembly lines. In the latter it has long been known that people do not work with equal efficiency at every moment of the day or night. Workers who start at 6 a.m. gradually become more and more efficient until a peak is reached at about 9 or 10 a.m. About noon a slight relapse occurs, which has been experimentally shown to be only partially connected with growing hunger or with a feeling of satiation after eating. This is then followed by a slight rise again, which at the end of the afternoon becomes a definitive decline. This curve in the trend of efficiency at work has been given the name of the physiological labour curve. Firms using an assembly line have tried to utilize this knowledge by adjusting the speed of the assembly line to this curve or, if this did not prove feasible, by adapting the number of parts to be assembled to it. The result was that the workers found the work less strenuous and in some cases production increased by five to ten per cent.

Shift workers usually have their turns of duty planned in such a way that they have, successively, the early shift, the late shift or the night shift; they usually change to a different duty every week. Consequently, these people are regularly subject to an eight-hour displacement in their periodicity phase. It has been found that it takes most people about four or five days before all their rhythms have adjusted fully to the new situation, during this whole period of time their rhythms are therefore desynchronized. As the workers undergo such a displacement in their periodicity phase every week, they are in actual fact in a constant state of desynchronization and readaptation. As tests on animals have shown that lengthy desynchronization of rhythms may give rise to pathological phenomena, these workers are really in a highly unfavourable situation. Doctors attached to the factory inspectorates of the various industrialized countries therefore often advocate a change of shift not every week, but preferably after two weeks or longer. However, this has proved impossible in practice, since a worker

who has to rest during the day does not get enough sleep and is already overtired after a week. On the one hand this is again a consequence of the existence of rhythms, which simply make it less easy for man to sleep during the day than at night; on the other hand this is aggravated by daytime noises, which are particularly troublesome in modern homes with their poor sound-proofing. Nowadays there are strong indications that the almost continuous disturbances of the phase interrelationships of the rhythms, at least in the case of many of these workers, are one of the reasons for the exceptionally large number of more or less serious mental and physical complaints among these people.

In various other fields, too, modern man may be confronted by the fact that he is subject to a daily periodicity of his life processes. For instance, airlines must take this into account when drawing up the duty rosters for the crews of their aircraft. Every one of us who has ever flown a great distance in a jet from west to east or *vice versa* knows that for a number of days after the trip the sensations of sleep and waking and of hunger come at the times usual before the trip, which of course do not at all match local time any more. Consequently, if possible, the crew's duty roster is always drawn up in such a way that these people do not have to undergo such phase shifts too often.

Finally, the astronaut is also faced with these problems. When he circles the earth in his space craft, e.g., every three or four hours, it becomes light or dark with the same frequency. A possible effect of these 'short days' may be nullified by applying continuous illumination, but care will have to be taken with this, too, since as the animal tests have shown, a desynchronization may occur between the various rhythms under such circumstances, too. A possible adverse effect of this continuous illumination (which is also coupled here with a constant temperature) will therefore have to be compensated for in some way or the other, e.g., by applying a strictly enforced alternation of work and rest. Observations have been made among future astronauts concerning the effects of, for instance, alternating four hours of work with four of rest, or eight hours of work with eight of rest. Measurements of the efficiency with which they performed various tasks demonstrated that a periodicity of about 24 hours continued to exist. It is therefore coming to be generally realized that if man lives under artificial conditions of continuous illumination and uniform temperature, he will have to impose on himself a rhythm in the alternation of work and rest with a period that does not differ too greatly from 24 hours; if he does not adhere to this he may endanger his health.

Having come to the end of my survey of the rhythm of light and life, I should like to say the following in conclusion.

I hope that I have been able to make it clear to you why the biologist in particular is so interested in the phenomena of periodicity. For, more than anyone else, he is confronted again and again with the universal occurrence and the many fascinating aspects of these phenomena. It is therefore logical that he has set about trying to find an answer to all the questions that arise in connection with their causation, their

function and their development in the course of evolution. Many of these questions will have to be answered by his own research, but for an answer to others he will have to call on the biophysicist, the biochemist, the physicist and the mathematician. It is pleasing to see that precisely this field of research offers a splendid instance of close and particularly fruitful cooperation between the representatives of all these fields of scientific study.

I hope, too, that I have been able to demonstrate to you that a thorough understanding of the causes and effects of periodicity phenomena is important not only to the biologist; the physician, the psychologist, the sociologist and the economist also benefit equally from it. They all must realize that periodicity is inherent in all phenomena of life and that this fact has consequences which are of the very greatest importance to man's well-being.

Classroom Experiments

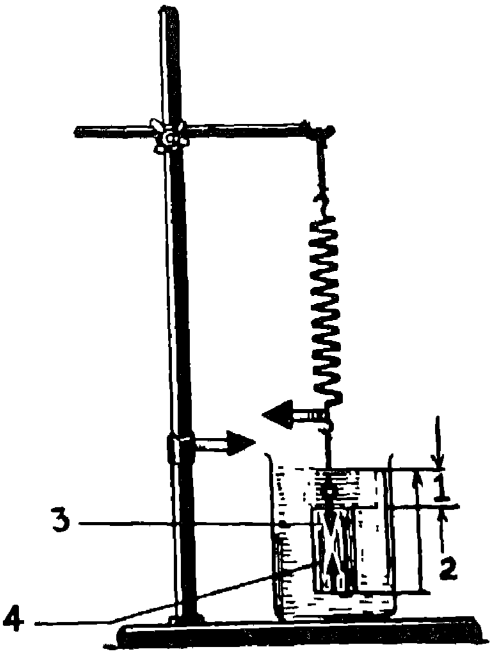


Fig. 1. The lower surface of the body experiences a greater force than the upper one; thus a buoyant force is created
1. Height of fluid above the body
2. Height of the upper surface of the fluid above the lower surface of the body
3. Force pressing the body downwards
4. Upward force experienced by the body.

Buoyant Force and Archimedes' Principle

K. J. KHURANA

THE presence of an upward buoyant force acting on a body immersed in a liquid can easily be demonstiated with the help of the apparatus shown in Figure 1.

In this apparatus a body is suspended from a spring. The length to which the spring is stretched is noted against a pointer fixed on the stand just opposite the pointer fixed at the lower end of the spring. The body is now immersed in water contained in a glass beaker. The spring contracts as evidenced by the upward movement of the pointer attached to the spring, to a position above the reference pointer. Had the body not been immersed in water, the pointer attached to the spring could still have been moved upward by applying some upward force at the lower surface of the body (e.g., by giving it a push with a finger). Evidently there is something that pushes the body up when it is immersed in water. What is this something?

When the body is immersed in water, the water surrounding it exerts pressure on it from all sides. The pressures on the sides cancel out one another. But the pressure acting on the lower surface of the body is always greater than that acting on its upper surface. This is so because the lower surface is always submerged to a greater depth. A buoyant force acting upward appears due to the difference in these two forces —a smaller force acting downwards on

the upper surface of the body, and a larger force acting upwards on the lower surface of the body. For the same reason other liquids also exert a buoyant force on bodies immersed in them.

To the question, 'On what does the magnitude of a buoyant force depend?' several answers may be suggested. The above apparatus can be used to investigate and verify the accuracy of these answers. For example, an experiment on the lines suggested in Figure 2. shows that the value of the buoyant that the magnitude of the buoyant force depends on the volume of the body immersed in the liquid and is directly proportional to the volume of the body.

Using liquids of different specific gravities (e.g., water, alcohol, aqueous salt solution) it can be demonstrated with this apparatus that the higher the specific gravity of the liquid the greater is the buoyant force (Figure 4).

Figure 5 suggests an experiment to demonstrate that a body immersed in a liquid experiences a buoyant force

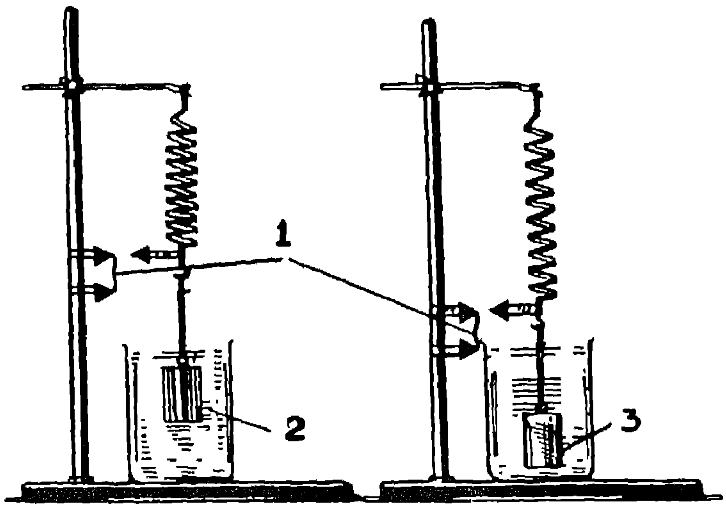


Fig 2 The lower arrow on the holder shows how much the spring stretches under the action of the body's weight in the air. The upper arrow shows how much the spring stretches when two cylinders of equal volume are immersed in water

1. Equal compression of the spring in both cases
2. Iron cylinder
3. Lead cylinder.

force does not depend on the weight of the body immersed in the liquid. Similarly the experiment suggested in Figure 3 can be used to demonstrate equal in magnitude to the weight of the liquid displaced by it. The principle expressed in this statement is known as Archimedes' principle.

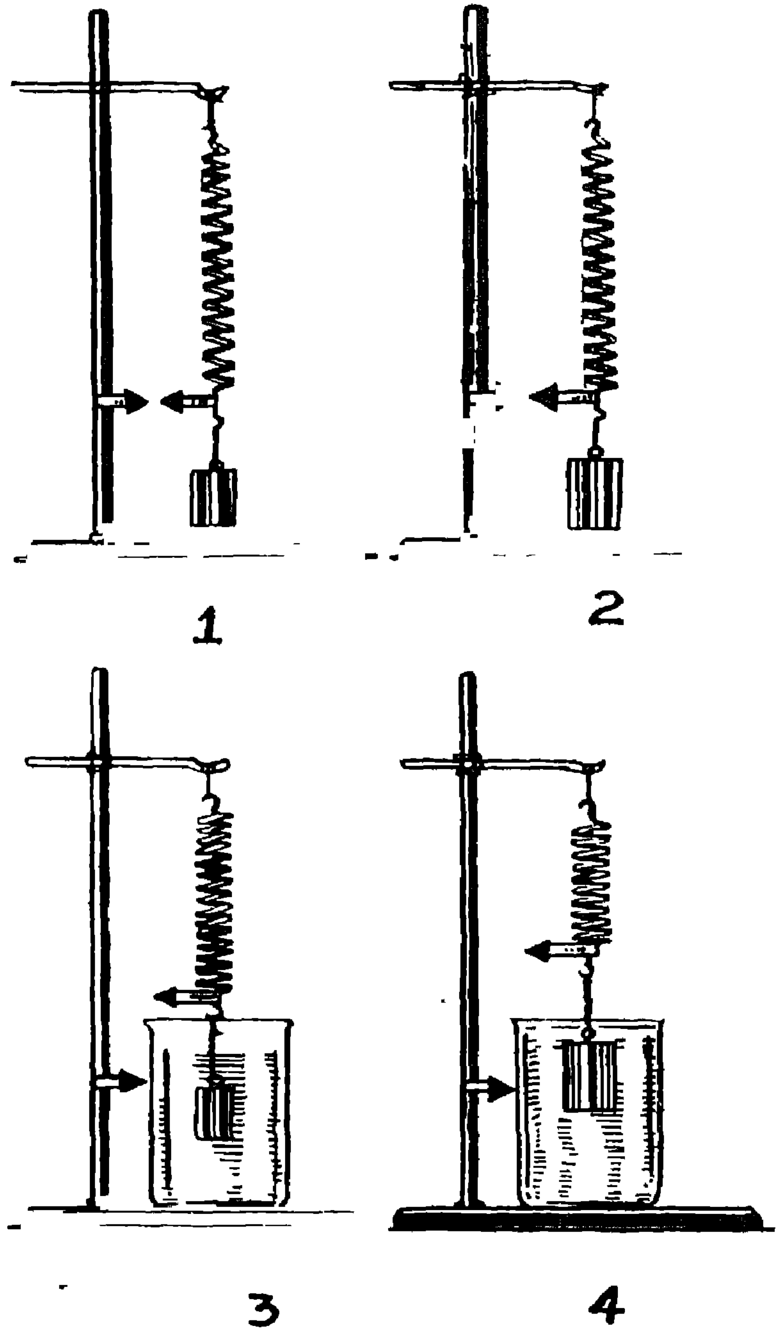


Fig. 3. Figures 1 and 2 above illustrate that the weights of aluminium and lead cylinders are equal.

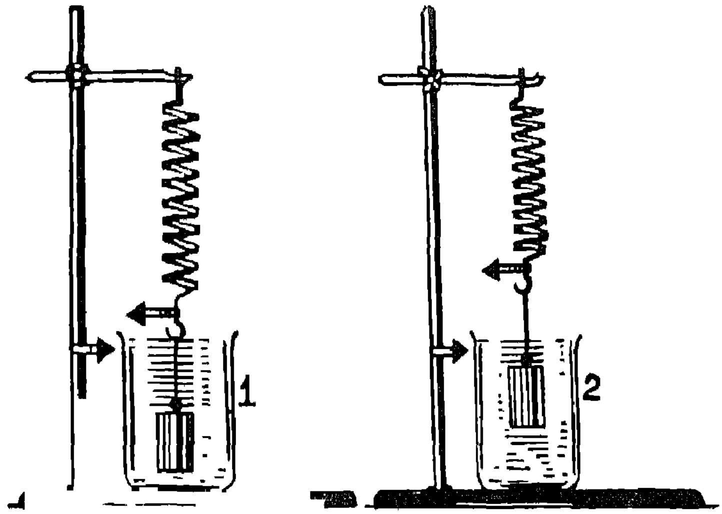
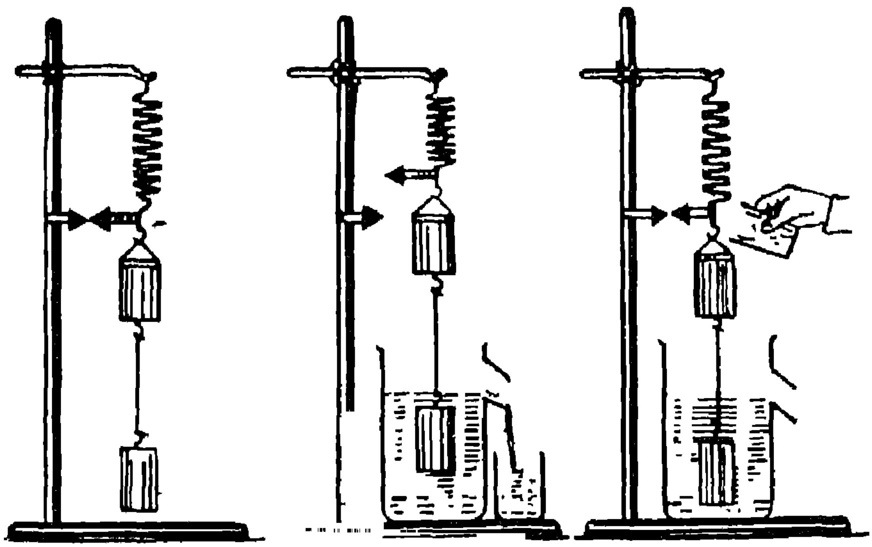


Fig 4. A greater force acts on the body when it is immersed in a liquid with greater density
1. Water
2 Salt solution



1 2 3

Fig. 5. Determination of the buoyant force.

Adapted from Physics for Class VI, *experimental edition of teaching materials prepared for the Project on Improvement of Teaching of Science and Mathematics.*

Science Abroad

Methods of Teaching Biology

I. D. Zverev

MOST significant for the success of the Unesco Experiment in Science and Mathematics Teaching is the employment of a great variety of methods of teaching, and their correlation. None of these methods of teaching may be considered to be universal or unique. Here we shall examine these methods and the principles underlying their classification and consider their employment according to the specific character of the school subjects.

Definition and Classification

The word 'method' in Latin means 'mode', 'way'. This word may express various meanings. In pedagogics it means method of teaching.

'Methods of teaching biology' is a pedagogic science and is closely interwoven with biology. It deals with the following problems: why do we teach? (aim and tasks of biological education), what do we teach? (contents of education), in what way do we teach? (methods of teaching and organization of school processes), how do children study? (process of studying).

Hence the problem of methods is significant. But what do we mean by 'methods'?

Methods of teaching. This means methods of delivering knowledge and skills by a teacher while teaching, and their comprehension by pupils in the process of studying.

This definition emphasizes the fact that the process of teaching is a two-sided process and is composed of teaching (teachers' activities) and studying (pupils' activities). The methods of teaching may be various and therefore need classification.

The most appropriate classification is the one according to the sources of knowledge The source of knowledge and skills may be the word (narration), object (image) or action (motion). From this we distinguish three groups of methods: oral, observation and practical.

Pedagogic research convincingly proves that we cannot give preference to any of these three methods; all three are resorted to in combination. Still, at any given lesson, we choose one of them as the main method. If the pupils react quickly to an object, the teacher uses the practical methods; if it is enough to demonstrate an object or its image the teacher chooses observation, and if an object cannot be demonstra-

ted the teacher uses oral methods.

Let us now consider each of these groups of methods in detail.

I Oral Methods

The word is the main source of knowledge. Both the teacher and the pupils widely use oral and written speech in the process of teaching and studying biology. A word, uttered and heard, delivers abstract concepts. According to Pavlov, the Academician, "The word being so characteristic of man is already abstract in itself."

We distinguish the following oral methods of teaching:

1. Talk
2. Narration
3. Lecture
4. Work at a book.

1. *Talk.* This may be delivered at a lesson, when·
   (i) it is possible to refer to the previously received knowledge;
   (ii) it is possible to refer to the pupils' experience;
   (iii) the teacher is demonstrating an object.

From the point of view of pedagogics, a talk which makes pupils draw conclusions is very valuable. In most cases a talk is addressed to the whole class, which acts as a collective interlocutor. In a talk one can see the pupils' active participation.

Suppose the teacher delivers a talk on the morphology of a bean seed. All the pupils are given bean seeds; after that the following talk may result.

Teacher: What is it that covers a seed?

Pupils: Coat, peel, veil, etc. (The teacher chooses the correct answer.)

Teacher. What is the colour of a bean seed?

Pupils Brown, black, etc.

Teacher. What appears when the coat is peeled off?

Pupils: Two halves.

Teacher: These are two cotyledons; move them apart, what is there between them?

Pupils: Leaves, bud, rootlet, tendril.

Teacher: Examine through a magnifying lens and find out to what the bud is attached.

Pupils: To a stem.

Teacher. What is the structure of the bean seed?

Pupils: The seed is covered by coat. It consists of two cotyledons, and has a rootlet, bud and stem.

Now the teacher asks the pupils to write down their conclusion and to sketch the structure of the bean seed. For the sake of recapitulation the teacher may ask pupils to enumerate and show on a chart the parts of the seed. This talk is closely interwoven with practical work.

A talk may be based on the demonstration of an experiment, a chart, etc. The teacher should always take care to ask correct and consecutive questions. Having estimated the answers, he should be able to compose new ones.

2. *Narration and Lecture.* They envisage a one-sided delivery of material by the teacher or pupil. The term 'narration' is applied to the act of describing objects and explaining the essence of phenomena and processes. It makes pupils comprehend the new material more systematically. For example, narration may be adopted when the teacher wants to tell pupils about the structure of a certain system of

organs, their functions and bonds. In this case the pupils actively listen to the teacher, visually comprehend the demonstrations, and make drawings and sketches. When we speak of active listening, we mean pupils' concentrated attention, their ability to give correct answers to questions put by the teacher in the course of the lesson, to express their opinion, etc.

A lecture is characterized by a more complicated content and is usually resorted to in Classes IX to XI.

Generally, a lecture is delivered when some material is generalized or some theoretical problems are explained, or a system of views held by scientists is introduced, or some problems of the history of science are presented (e.g., the theories of Lemarck, Darwin, the development of evolutionary views in biology, etc.).

The following most important requirements of narration and lecture should be kept in mind:

(i) figurativeness, vividness, picturesqueness of delivery

(ii) consecutiveness in revealing the main problems

(iii) validating conceptions and ideas by examples and facts; drawing conclusions; summarizing

Pupils should be taught to practise narration with, and deliver lectures to, their classmates.

But both narration and lecture are always used only in combination with the other methods. During a narration or lecture the teacher should demonstrate experiments, models, charts, natural objects, etc. This is the correct way from the point of view of methods of teaching.

3. *Work at a Book.* The pupils' ability to work at a text and pictures must become a component part of the process of teaching, they should do this not only while studying a lesson at school, but at home as well

It is important that the teacher should organize a variety of methods for work by pupils at a textbook, as given below

(i) *Retelling of the text.* This method is often resorted to at school. It helps pupils to conscientiously comprehend the contents of the theme, and promotes their speech and thinking. Retelling of a text begins with the most easy material (e.g., monographic description of a plant, its application, its characteristics, the structure of its parts, etc.).

(ii) *Explanation of pictures and sketches.* This type of work envisages pupils enumerating the parts of a bean seed (all inscriptions to be covered with a piece of paper); checking of the fulfilled task, describing of the outer structure of a tree by its picture; detecting by schemes corresponding pictures of floscules, etc.

(iii) *Answering questions.* The teacher may utilize the questions given at the end of each paragraph or put his own questions on the text. The pupils' answering such questions is a very useful exercise.

(iv) *Working out a plan to the text.* The teacher employs this method when the pupils work at a complicated text embracing a number of difficult problems (e.g., composition and properties of soil; types of stems; types of vegetative reproduction.) A plan may be composed by pupils to the paragraphs dealing with generalization and deduction

(v) *Looking for additional facts.* For example, pupils may refer to mono-

cotyledons and dicotyledons or to plants having different type of roots, etc.

(vi) *Conducting an experiment or observation according to the textbook.* Textbook instructions and tasks help pupils integrally to comprehend theory and experiment. Thus pupils may conduct experiments revealing the impact of water and air on seed germination; evaporation of water by leaves; results of root grafting, formation of the crown of a tree, etc

Work at a textbook is closely interwoven with the pupils' work at their notes. Pupils may make notes and sketches in their biology note-books not only during lessons at school, but at home as well. These notes and sketches may be as under:

a. Writing the syllabus and lesson themes
b. Writing the plan of the lesson, the succession of main problems
c. Writing home task
d. Writing deductions and conclusions
e. Composing comparative schemes and classification charts
f. Sketching the schemes of the setting of an experiment; fixation of the results of an experiment
g. Writing out independent work; book review, etc.

II Observation Methods

They are based on the combination of word and image. These are combined in three forms:

1. Image before word
2. Word before image
3. Word and image interwoven.

Psychological research has proved the first and the last forms (the last, especially) as being most effective from the point of view of pedagogics. At each lesson the teacher may use natural objects, charts experiments, slides and films.

A folk saying runs: 'To show once is better than to narrate a hundred times'. Observation methods envisage interweaving various forms of activity. demonstration by teacher and comprehension (observation) by pupils Hence, while using observation methods, one should stress the unity of teaching and studying.

The various kinds of observation methods are·

1. Demonstration of natural objects
2. Demonstration of charts and models
3. Chalk drawing
4. Demonstration of slides and films.

1. *Demonstration of natural objects.* The pupils' knowledge of biology is incomplete and formal, if they are not acquainted with the flora and fauna. The teacher should demonstrate the natural objects (plants, animals) which the lesson is about—for example, corn, vegetables, ornamental and medicinal plants, insects, fishes, frogs, lizards, birds, molluscs, and so on. This facilitates the study of nature in its natural form. It is very important to ensure a complete observation of the appearance of live objects, i.e., the study of the properties and features which cannot be observed on dead specimens.

The demonstration of natural objects arouses a great interest in the pupils, impresses them, and promotes the building up of sound knowledge. The teacher should always think out before-

hand a system of questions for a talk with the class that is conducted on the basis of observation of live objects. Small objects (e.g., plants) should be distributed among pupils for study according to certain instructions. Almost at every lesson the teacher should demonstrate actual but not live objects (herbariums, stuffed animals, skeletons, collections, preparations, etc.). It is very useful to distribute these objects among pupils, to outline the aims of observations, to give questions for answering, and to draw conclusions out of the analysis of the facts accumulated in the process of observing objects.

2. *Demonstration of charts and models.* If it is not possible to demonstrate natural objects, the teacher should resort to visual aids. Charts, models, etc., are used in combination with the demonstration of natural objects. A model or a chart emphasizes some phenomenon or property, facilitating its detailed study and affording a comparison with a natural object.

For example, we may take a model or a chart of the morphology of a flower and its actual parts; a vivisection of a frog's heart and a model of a heart; a stoma under a microscope and a model of the section of the cells of a stoma, and so on.

3. *Chalk drawing.* This is widely used in the process of introducing new material or in recapitulation. It focuses pupils' attention on the main features and promotes building up of spatial ideas. To single out the most significant features of an object, a drawing must be simple, expressive and legible. A drawing should appear on the blackboard simultaneously with the explanation or oral introduction. Example: A schematic drawing of the structure of a cell may appear, part by part simultaneously with the explanation of the main features:

> A cell is a bit of protoplasm. It contains a nucleus, and cytoplasm. There is cell sap in the vacuoles. The cell is covered by a wall

To complete the drawing, the teacher should label the parts of the cell.

Drawings may be:

i) *Symbolic*

Inflorescence	A complex size
Cluster	

ii) *Schematic*

Flower	Woodpecker
Fruit	Butterfly
Stem	
Leaf	
Root	

The teacher should use coloured chalk to enumerate parts of an object, giving labels. Pupils start copying into note-books after the teacher finishes sketching and explaining the new material.

4. *Demonstration of slides and films.* Slides and films reproduce nature, facilitate comprehension of material irrespective of place and time, and portray the dynamics of phenomena.

It should be emphasized here that a film should be always subordinated to the contents of a lesson. Before projecting a film the teacher should assign some task; give, if necessary, short explanations while projecting the film, discuss the projected material (talk, narration, new examples, written answers).

It is very advisable to project a film bit by bit. It helps the teacher to check the pupils' conscious compre-

hension of the film, to throw light upon the most difficult problems, and to introduce complicated concepts by parts. Having reviewed a part, the teacher conducts a talk, the pupils make sketches and observe other demonstrations, etc. Thus, projection of films is closely interwoven with other auxiliary methods. Films are used as accessory, but not independent, study material.

III Practical Methods

Practical methods bring the pupils close to the object to be comprehended.

These methods envisage conducting experiments, observations and laboratory work. Experiment and observation as methods of teaching reflect specific methods of biological research. That is why their use is of the utmost significance in revealing physiological conceptions, e.g., absorption of water by a root, photosynthesis, transpiration, movement of substances in plants, vegetative reproduction, pollination, etc.

If the experiment as a method of teaching is not utilized sufficiently it cannot be guaranteed that the pupils will properly comprehend physiological processes and in fact a number of other biological problems, for the comprehension of physiology is closely interwoven with the comprehension of the structure of organs, evolution, development of organisms, etc.

Now let us consider the main methodological requirements of our experiments at school level.

First of all the aim of the experiment should be determined and compared with the control experiment. Then the changes that occur in the process of the experiment should be observed, their reasons explained, and conclusions and deductions made.

School experiment should not be complicated; they should be simple and clear, and should produce results. Let us take an example:

1. Evaporation of water in leaves.
   i) *Control.* Water with a film of oil on its surface.
   ii) Water without oil on its surface.
   iii) Water with oil on its surface and a twig with leaves.
   Deduction. Leaves absorb water.
2. Cutting of root,
   i) *Control.* The end of the root is preserved.
   ii) The end of the root is cut.
   Deduction. Cutting of the end of the main root results in the development of lateral roots.

The results of the experiment should be registered in the form of a sketch, collection, herbarium, diagram, etc.

Long and short experiments may be carried out in the school. The teacher should know beforehand when and how to start an experiment and the results it should give.

There are two ways of utilizing experiments at school:

1 Illustrative
2. Research.

In the first case an experiment proves or illustrates an already known idea, rule or law. For example, the teacher says: "Seeds contain water; let us observe this." (Demonstration of an experiment.)

In the second case, the teacher says: "Let us find out what substances seeds contain; let us heat them. What is seen on the cooler parts of the test-tube walls?"

Answer. Drops of water.

Question. What do seeds contain?

Answer: Water.

Thus, the illustrative experiment only proves material already introduced, while the research experiment relies on the pupils' anticipation. That is why the research experiment is to be preferred.

Choice of Methods

What are the points that a teacher should consider while choosing methods? First of all, the specific character of the contents. For example, anatomical and morphological concepts are mainly studied with the help of practical methods; physiological concepts, with the help of observation methods (demonstrations, experiments); systematic concepts (taxonomy), with the help of practical and observation methods; and general biological concepts, with the help of oral methods.

Secondly the choice of methods depends on the aims of teaching, and the importance of forming correct, complete and sound concepts and ideas, and building up pupils' skills.

Then again the choice of methods depends on the age and peculiarities of the children and the requirements of the psychology of that age. For example, the lecture may be resorted to only in the senior classes. In the junior and middle classes, the teacher uses a greater variety of methods than in the senior classes. The duration of using one and the same method in junior classes is shorter than in the senior ones.

In conclusion, it should be emphasized once more that none of the methods, as a rule, can be used independently. All the methods are used in combination and are developed with the development of the pupils' knowledge.

Generally, each method should be active, should make pupils think and should arouse their interest in the subject. These methods develop the abilities of comprehension, comparison, generalization and deduction. Pupils should be taught to master the methods of studying, listening, observing, registering, experimenting, and so on.

Thus, methods should stimulate pupils' school activity. Besides, each method may be supplemented by other specific methods to motivate the process of learning. The problem of motivation for teaching also needs to be studied

Young Folks Corner

Microscopic living germs (microbes, micro-organisms), some harmless, some dangerous to human beings, are almost ubiquitous in the air and on the surface of every living being. They are in the dust that deposits on most solid substances, they are always present in stagnant water. Skin protects man from their evil influence, but if the skin is injured, or cut by the surgeon, harmful microbes will settle on the raw surface and cause serious complications, unless precautions are taken.

The great achievement of Joseph Lister was to devise a satisfactory method of preventing microbes from entering wounds. Thus he opened the door to the development of modern surgery.

Joseph Lister

LISTER'S WORK OF 100 YEARS AGO OPENED THE DOOR TO MODERN SURGERY

ZACHARY COPE

Joseph Lister

EXACTLY 100 years ago Joseph Lister, Professor of Surgery at the University of Glasgow, then just under 40 years of age, began those experiments in the treatment of wounds that were destined to lead to a revolution in surgery.

It is difficult for the present generation to understand what a great change in outlook and practice resulted from the adoption of a comparatively simple procedure.

Until anaesthetics were introduced in 1846 surgery was extremely limited in scope because of the unavoidable pain. Yet even when anaesthesia became available, surgery scarcely advanced for another generation because wounds, whether accidental or made by the surgeon, usually developed serious inflammation or even hospital gangrene.

This frequently led to the death of the patient, or at least the loss of a limb.

One day Lister said to his students:

> Trouble of the gravest kind is always apt to follow, even in trivial injuries, when a wound of the skin is present.

Reprinted with permission from *Spectrum* August 1965, 15:3-4

> How is this? The man who is able to explain this problem will gain undying fame

He did not then know that he was to be that man.

The surgeons of that time were not highly educated men, and few were capable of scientific research. They regarded inflammation of wounds as an unavoidable misfortune due, perhaps, to bad ventilation or insanitary conditions, or even to some indefinite miasma in the air. That living germs might be the cause never occurred to them, and if it were mentioned, they ridiculed the idea.

Early in the year 1865, Lister was one day walking with his colleague, Dr Thomas Anderson, Professor of Chemistry in the University, when the latter mentioned that in France Louis Pasteur had recently proved that certain fermentative and putrefactive processes were caused by the action of living microscopic germs. Fermentation could be stopped by heating the fluid, but would start again if the fluid were exposed to the air. Pasteur concluded that the living germs were present in the air.

Lister, who at that time was much worried by the bad results of his surgery owing to the inflammatory complications following operations, wondered if his troubles might be the result of microscopic germs which settled on the raw surface of the wounds. If this supposition were correct, the remedy was to prevent their access to the wounds, and he set about testing this view. He determined to apply to wounds some substance which they could not penetrate.

From Dr. Anderson he obtained some crude carbolic acid (creosote) that was known to prevent putrefaction in sewage, and he soaked some lint in this substance and applied it as a dressing to the raw surface of some patients who had sustained the type of injury known as a compound fracture (a broken bone with the overlying skin torn open) injuries which were usually followed by amputation of the limb and sometimes by the death of the patient.

The results were good beyond his expectations

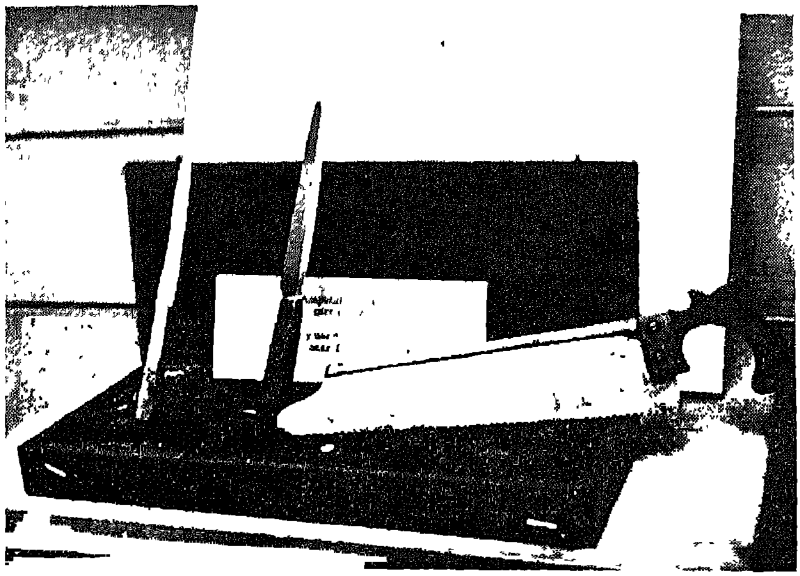
In his own words.

> Applying it undiluted to the wound, with an arrangement for its occasional renewal, I had the joy of seeing these formidable injuries follow the same safe and tranquil course as simple fractures in which the skin remained unbroken.

Lister next tried similar methods in the case of operation wounds, but he also soaked the instruments, the towels, the sponges, and even his own hands for a short time in a solution of one part of carbolic acid in 20 of water. To his delight he found that with these precautions he was able to perform many operations quite safely (for example, on bones and joints) that previously would have been regarded as unjustifiable. The scope of surgery was thus vastly extended.

Lister's antiseptic technique was treated with ridicule by some surgeons, ignored by others, tried half-heartedly by a few of the older surgeons, and only taken up by a few of the younger surgeons in Britain.

In Germany and Scandinavia, however, several prominent surgeons adopted it and found that it transformed their surgery by lessening the risk and extending the scope. Within 20 years antiseptic surgery was generally



Crude operating equipment for amputations, probably used by a London surgeon in 1825.

accepted.

In time Lister modified many of his methods For a while he tried a spray of dilute carbolic acid to purify the air in the operation-area, but he gave up this in 1887. As a wound dressing he abandoned carbolic acid, tried many other chemicals and finally settled on gauze impregnated with the double cyanide of mercury and zinc.

He continued to prefer dilute solutions of carbolic acid for sterilizing instruments, towels, sponges and for preparing the skin of the site of operation, and for his own hands.

The microbes that were the chief cause of the inflammation had in the meantime been discovered and named staphylococcus and streptococcus. The theory on which the antiseptic system was based was proved correct.

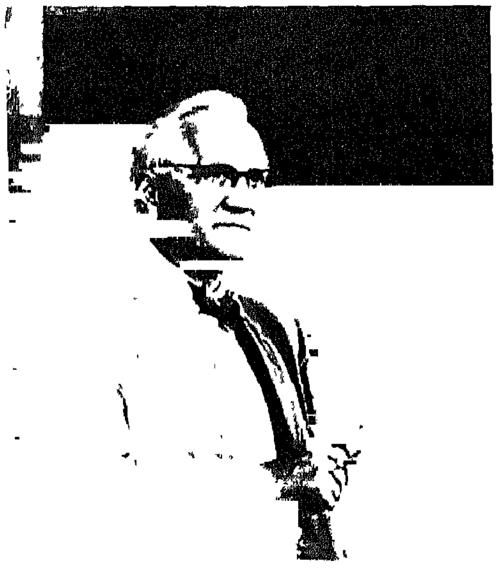
Some surgeons thought Lister's procedures too complicated and adopted other methods of getting rid of the microbes. They boiled their instruments, heated the towels, dressings and mops in high-pressure steam sterilizers and protected the wound from contact with their clothes and hands and breath by wearing sterilized gowns and rubber gloves, and covering their faces with sterilized masks. This aseptic technique gradually became widely used, but it was long before it displaced the antiseptic system.

When I was a medical student (1900-1905), sterile gowns were just coming into use, but masks were not used until ten years later. The aseptic method is now used in almost all operating theatres, but there are still occasions where antiseptic methods are needed.

Lister never claimed that microbes settled in the deep parts of a wound could be destroyed or got rid of by the application of antiseptics. In the war of 1914-1918 the gunshot wounds were usually much contaminated and septic

and it was found that none of the ordinary antiseptics had much effect on them.

Moreover, Almroth Wright and Alexander Fleming showed that in such cases carbolic acid and most other antiseptics did more harm than good. Later, flavine and the hypochlorites were found more efficacious, but they did not fully solve the problem and by the end of the war it was generally agreed that the best method of getting rid of deep infection in a gunshot wound was to operate as soon as possible and excise foreign bodies and damaged tissue.



Alexander Fleming

The remaining healthy tissue was usually able to look after itself. This mechanical method gave better results, but it did not really solve the problem either.

Ehrlich's discovery that a synthetically prepared drug, which he called salvarsan, was able to rid the human body of the spirochaete of syphilis encouraged surgeons to look for some drug that, taken internally, might free the body from serious septic infections, but the probability of success seemed remote.

Then, in 1935, Domagk discovered a sulphonamide derivative – prontosil – that had a specific destructive effect on streptococci, the most deadly septic organism.

The use of the sulphonamides enabled much better results to be obtained in the treatment of gunshot wounds during the early part of the 1939-45 war.

However, even before Domagk's discovery was made known, Fleming had, in 1928, discovered a substance which he named penicillin (since it was obtained from the mould *penicillium notatum*), which had a most powerful effect against the common septic organisms. This was the first and the most useful antibiotic.

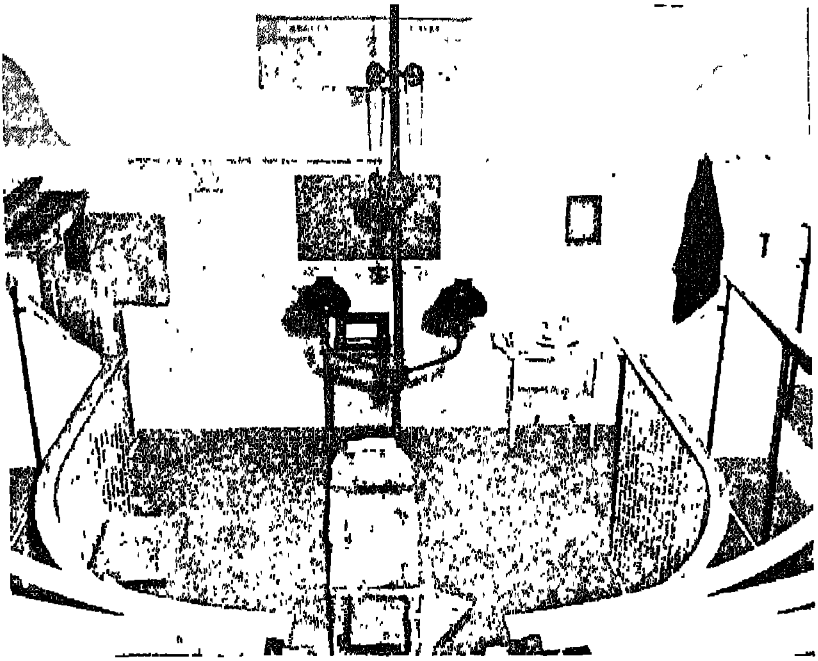
Unfortunately, Fleming could find no chemist who was able to stabilize and concentrate this substance. But in 1943, Sir Howard Florey and Professor Chain were successful in doing this, and soon penicillin became available for treating war wounds and other septic conditions, even when the microbes had gained a serious hold in the tissues.

This discovery ushered in a new era of surgery. Some very dangerous diseases—acute osteomyelitis, erysipelas, cellulitis, and even septicaemia, became curable or preventable. Penicillin also enabled some operations to be safely performed that previously had usually been fatal. To those of us who had practised in the pre-penicillin era it seemed like a miracle.

Surgeons at work in aseptic conditions in a modern operation theatre

The aseptic technique has been carried by some surgeons to the extent that they arrange that all the air that enters into the operating theatre is passed through filters that stop the entry of any microbe. This method needs the most careful attention if it is to remain reliable.

A special application of it was devised by Leonard Colebrook to prevent in-



Early type of operating theatre, recently restored, which shows the conditions under which early ninteenth-century surgeons worked and taught.

fection of extensive burns. Septic complications are a frequent cause of death in burns. Colebrook applied a penicillin dressing, and every time it was changed the patient went into a room made aseptic by filtering all the air that entered. By this means the extensive raw surface was kept clean and it was possible to carry out early skin-grafting. Now that large units are arranged for treatment of burns this method can be applied with great success.

Since penicillin was discovered, other efficient antibiotics have been sought for and found. It has been discovered that certain strains of microbe become resistant to particular antiseptics or antibiotics, but it is now possible to change the antibiotics when necessary.

There is always the possibility that some other chemical may be found that will kill the microbes in the depth of a wound without damaging the healthy tissues, and without toxic effect. The antiseptic method will then again become popular.

Science Notes

Sodium Hydroxide from the Sea

CAUSTIC Soda is reported to be produced economically from sea water on a commercial and economic scale by a new ion-exchange process developed by Asahi Kasei Kogyo K.K., 25-1, Dokimahamadori-1 Chome, Kita-ku, Osaka, Japan.

Sea water is fed to a column where it reacts with a special resin which converts the salt in it to sodium hydroxide. The resin is regenerated with a lime slurry and used over and over again.

The Drill That Can Go Round the Corner

TIME is an important factor in the hunt for oil and gas. So anything likely to reduce drilling time by even a few days is carefully considered. A technique known as turbo-drilling is expected to achieve just this. The first company to employ it in the North Sea is British Petroleum. By the autumn they may well be more advanced than anyone else in the application of this technique.

They will then be using a turbo-drill developed by Sir Frank Whittle, the jet engine pioneer. The turbo-drill is a long pipe made up of individual sections, which are added gradually as you go drilling further down, and the whole of this assembly rotates along its complete length. It is easy to see that once you have started drilling, with a huge straight shaft like this, departing from the straight path is something of a problem It can be done by fixing various devices, but this is time-consuming and costly. It was to ease this problem that turbo-drills were developed. With this technique, the drill itself, that is the long shaft that goes down the hole, does not rotate. The only thing that goes round is what is known as the bit—the part that actually bites into the soil. This is turned by a turbine motor which itself is driven by the pressure of the mud pumped into the drill pipe.

The Russians and the French are producing such turbo-drills, and it is a French type which is at present being used by British Petroleum in their North Sea operations. It will enable them to drill several wells from one and the same platform, going radially like the spokes of an umbrella. This is done by fitting an angle joint above the turbine which causes the bit to follow a curved path. The curve is gentle enough for the pipe supporting the drill to follow easily.

Turbo-drilling, however, does not mean abandoning the conventional type of rotary drilling. What is done in fact is this: you drill a straight hole with the conventional drill; then the turbo-drill is used only for the deviation, after which you go back to the conventional drill.

Turbo-drilling is claimed to be between two to three times faster than conventional drilling, but the turbo-drill has a short life. You have to keep pulling it in and out of the hole. And therefore, as you go down deeper, the advantage is lost. On the other hand, turning corners with a conventional drill is time-consuming and it is reckoned that the turbo-drill can save four or five days out of the seventy which is the average time for drilling a well. If the problem of repairs could be eased—it, in other words, the turbo-drill could be made less vulnerable—the potential savings could be very much greater. Such a drill will be available by the autumn of this year. It has been developed by Sir Frank Whittle in cooperation with Bristol Siddeley, and it will be available by the autumn of this year.

Whittle's design is expected to go a long way towards overcoming the drawbacks of existing French and Russian turbo-drills. Basically, it introduces a gear-box into the conventional multi-stage turbine, which will result in a very much longer life for the 'bit' or cutting part—the most vulnerable part of the turbo-drill. British Petroleum plan to put the Whittle drill into operation some time in the autumn. This drill should enable them to exploit their wells at an even faster rate.

Metal Cutting Machines

SOLID round bars, 2 inches in diameter, tubes of 3½ inches diameter and sections up to 5 by 3 inches can be cut by the latest sawing machine to be produced by Cave-Cut Machine Tool Company, Meadow Hill, Portwood, Stockport.

Suitable for cutting aluminium, brass, copper and mild steel, it is claimed to give clean, accurate cuts free from burrs. Because the head carrying the driving motor can be moved through 90 degrees, slots and notches can be cut at any desired angle.

The motor drives the 11-inch diameter saw blade *via* a gear-box and gives speeds of either 40 or 80 r.p.m. The machine can be supplied as a bench model or mounted on its own steel stand.

Another metal cutting machine—now being marketed by Channel Tool Distributors, of Eastwood Street, Mitcham Lane, London, S.W.16 — is the VMS 111 circular saw which will cut steel, iron and non-ferrous metals. This machine is stated to produce quickly an accurate burr-free cut and among its applications are straight and mitre cutting, 45 degrees right and 45 degrees left, pipe saddling and slitting profiles and shapes of all kinds.

Motor and gear units can be swivelled through 180 degrees for any straight or mitre cut required. The material to be cut always remains in the same position.

Ultra-precision Radiation Meter

BRITAIN'S Bush Murphy Electronics' radiation monitoring apparatus, called a Scintillation Gamma Monitor, is claimed to be the most accurate of its kind in the world. They claim it is

twice as accurate as any other when measuring extremely small amounts of radiation. It is about the same size and weight as a shoulder-strap transistor radio and was developed in cooperation with the United Kingdom Atomic Energy Authority. It is designed for service anywhere—you can even use it underwater. And it is not only for use in the nuclear industry—it can even help people like water-supply or sewage disposal authorities. If, for instance, you're looking for a blockage in a pipe buried underground, you can put a radio-active source into the pipe, and follow it with the radiation monitor above ground. This sounds as if it could be dangerous, but the monitor is so sensitive that a very weak, and therefore safe, source of radio-activity can be used. Biologists have even used it for tracking worms or insects that have been what is known as 'labelled' with a minute amount of radio-activity material because anything else would obviously damage the living organism.

Can Drugs Improve Bad Memory?

A drug which has been on sale in Britain for many years as a mild stimulant has suddenly become of intense interest to scientists for an entirely different reason: it may help to improve bad memories, particularly in the aged, and to increase the speed at which people can learn.

At a recent meeting in the United States of the Society for Biological Psychiatry, Dr. Ewan Cameron, a brain-drained Scottish doctor, described the results of the first trial of the drug with human patients. At the Veterans' Administration Hospital in Albany he administered it to a group of people whose memories were failing because of senility or hardening of the arteries in the brain. A similar group received a dummy pill of similar appearance.

The patients who took the drug did significantly better in tests, such as the reproduction of drawings of which they had had a brief glimpse and the pairing of words like 'baby' and 'cries'. The drug used by Dr. Cameron is made by Abbott Laboratories of Chicago and is called Cylert. It consists of a mixture of common magnesium hydroxide and a substance called pemoline. Cylert has not yet been passed by the Food and Drug Administration in the United States.

Pemoline, presumably the active constituent, has been sold in Europe as a mild central nervous system stimulant for years The amphetamine group of drugs (used in purple hearts) have a similar action. Pemoline, it is claimed is non-habit forming.

Nuclear Submarine Commissioned

The first all-British nuclear fleet submarine *Valiant*, 3,500 tons, has been commissioned recently at Vickers Naval Yard, Barrow-in-Furness The *Valiant*, laid down in January 1962, is 16 feet longer than her predecessor, the *Dreadnought*, whose nuclear propulsion machinery is American. Her speed is said to be well over 30 knots, and she is armed with six torpedo tubes fitted for homing torpedoes.

Great attention has been paid to amenities for the 12 officers and 90 men. Fresh water is supplied from a distillation plant and there are six showers. Each mess deck has a cinema screen and the senior ratings' mess has a carpet fitted.

By courtesy: *Science Newsletter*, Indian High Commission, London

Australian Scientist for U.N. Post

A leading Australian scientist, Mr. Guy B Gresford, has been appointed to a United Nations top scientific post as the first Director of Science and Technology in the United Nations Department of Economic and Social Affairs Mr. Gresford will head the secretariat of the United Nations Advisory Committee on the Application of Science and Technology for the less developed areas.

The Advisory Committee has already held a number of meetings and is drawing up plans to accelerate the application of science and technology in the field of development. It has worked closely with the specialized agencies of the UN which are largely responsible for action in this field. Its work has covered such fields as the establishment of basic scientific structures in the newer countries, the application of existing knowledge, improving documentation services in developing countries and problems of scientific education.

Mr. Guy B. Gresford

Mr. Gresford was appointed secretary of the CSIRO in 1959. He has also been closely associated with the Commonwealth Scientific Committee and with UNESCO activities in South-East Asia, dealing with science administration.

By courtesy, Australian High Commission, New Delhi

Problems in Mathematics

J. N. Kapur

R. C. Sharma

Solutions of problems SS20 to SS25 printed below should reach the Editor, School Science, *NIE Buildings, Mehrauli Road, New Delhi by 31 December 1967. Each problem should be solved on a separate sheet of paper and should bear the name of the student, his class and his school and should carry a declaration that he has solved the problem himself. Persons other than students can submit solutions, but they will not be eligible for any prizes that may be awarded.*

Correct solutions of problems SS1 to SS19 (see School Science, *March 1967 and June 1967) together with the names of those who solve them correctly will be published in the December 1967 issue of* School Science

SS20 (i) Two numbers, a and b, are such that a is smaller and b is greater than 1. If S is the sum of a and b and P is their product, prove that S and P differ by more than 1.

(ii) Hence show that if the product of two positive numbers is 1, their sum cannot be less than 2.

(iii) Using this result, or otherwise, prove that amongst all right-angled triangles of equal area, the isosceles triangle has the shortest hypotenuse.

SS21 ABC is an equilateral triangle and P is a point on the circumference of its circumcircle. Prove that one of the distances, PA, PB and PC, is the sum of the other two.

SS22 ABC is an equilateral triangle and P a point inside the triangle. Perpendiculars are drawn from P to the sides, the feet of the perpendiculars being X, Y, Z. Prove that PX+PY+PZ is constant for all positions of P.

SS23 Replace the letters by digits to make the following addition correct:

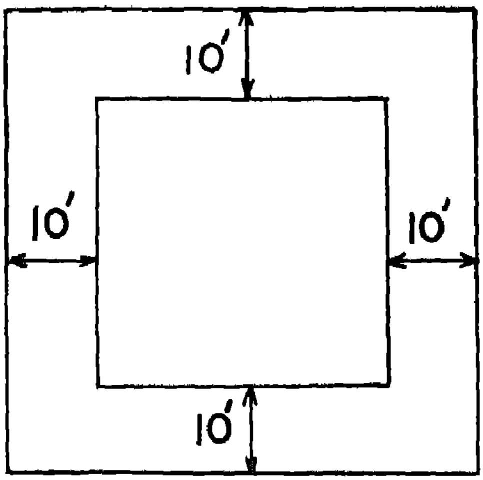
AHAHA+TEHE=TEHAW

SS24 The sides of a quadrilateral ABCD are of fixed length, but the angles may be varied. Prove that its area is the largest when it is cyclic, by using the isoperimetric property of the circle.

SS25 (i) Show that 5 −1 is divisible by 4, $n \in N$

(ii) A piece of paper 1/200 in. thick is folded 50 times. What is its thickness now?

(iii) How will you cross the ditch shown in the diagram below if you have two planks, each nine feet long?



New Trends in Science Education

Summer Institutes Programme

The Summer Science Institutes for Secondary School Teachers held in 1966

S. DORAISWAMI

We reproduce below extracts from the Report of a Contract Education Project for Summer Science Institutes for Secondary School Teachers in India. It is expected that these extracts would be useful to those interested in this project. For further details readers may refer to the Report.

EDITOR

FORTY-THREE Summer Institutes for Secondary School Teachers were held in the summer of 1966. These were situated at University centres as follows:

BIOLOGY :	Agra, Bombay, Delhi, Indore, Trivandrum, Madras and Ranchi.
CHEMISTRY :	Annamalainagar, Bangalore, Burdwan, Chandigarh, Gorakhpur, Hyderabad, Jadavpur, Poona, Ujjain, and Vallabh Vidyanagar.
PHYSICS :	Agra, Aurangabad, Bangalore, Chandigarh, Patna, Rajarammohanpur, Saugar, Tirupati, Varanasi, and Waltair.
MATHEMATICS :	Burdwan, Delhi, Jodhpur, Jabalpur, Kurukshetra, Madras, Nagpur, Vallabh Vidyanagar, Varanasi, and Waltair

Nearly 1,516 secondary school teachers participated in 39 institutes held under the auspices of the T.C.C.U. team (data not available for four institutes held in the Regional Colleges of Education with the cooperation of the Ohio State Team.) Of these participants, 269 were biology teachers, 381 chemistry teachers, 423 physics teachers and 443 mathematics teachers. The names of the Directors and staff members of these institutes and those of the American Consultants assigned to them have appeared in the earlier issues of this journal.

This is the fourth year of the Institutes programme, the institutes have been quite successful. There is no doubt that they are achieving the purpose of stimulating teachers to change their understanding of science and learn new ways to improve their teaching.

A programme of this kind required the energy and cooperation of many people from the Ministry of Education, National Council of Educational Research and Training, the University Grants Commission, the Indian universities which supplied the Indian directors and teaching staff, the A.I D. in Washington and New Delhi, the TCCU Team in India, the National Science Foundation, and the American scientists. These people worked as a group to launch this successful programme.

The purpose of these institutes has been twofold: (i) to bring to the attention of Indian teachers of science and mathematics recent developments in the field of science and in methods of teaching science which produce in the learner the characteristics of a scientist; and (ii) to introduce new books, manuals, and instructional aids for improving the teaching of science, particularly in the secondary school and to make these desired and, to a large extent, adaptable in India. The institutes have been successful in these two objectives. They have however not produced major changes in classroom teaching and cannot be expected to do so until changes have been made in the syllabus, instructional materials, and the external examination. Unless this is done properly and promptly, the institutes will fail to bring about any significant change in instruction in the classrooms of India.

As in the previous years, this year too PSSC materials were used in the physics institutes, CHEMS materials in the chemistry institutes, BSCS materials in the biology institutes, and SMSG materials in the mathematics institutes. These provided the texts, laboratory manuals, films, and other materials which served as vehicles for achieving the objectives of the Summer Institutes. It was not the intention of the Summer Institutes programme in India to train Indian science teachers in how to teach the American materials, these institutes have used these modern materials to achieve their own objectives.

The Institutes as Instruments of Change in Indian Science Education

Education is a State subject in India. There are, therefore, as many syllabi for any discipline as there are States. A study of these syllabi, however, shows that they have more in common than one might expect. Many of the best participants in the institutes have said that there was very little they could do to utilize their institute ex-

perience in the teaching until changes were made in the syllabi or until they were authorized to depart from them.

The nature of the external examination system in India militates against change in the formal and didactic system of science teaching that constitutes the norm. In general, this system is one of lecturing on the part of the teacher and note-taking on the part of the students, attempts by the students to commit the lecture notes to memory in preparation for the external examinations, occasional demonstrations by the teacher. Finally, where laboratories exist, formal laboratory exercises complete the normal teaching-learning picture

In summary then, the Institutes programme is attempting to improve science teaching, the present position regarding which may be briefly summed up as follows:

1. The majority of schools have little or no laboratory equipment.

2 Teachers are expected to follow the syllabus closely, and the science syllabi are such as enforce the descriptive and didactic process of teaching.

3 It is not unfair nor inaccurate to state that teaching and learning are done primarily for the purpose of passing examinations rather than for the intrinsic values of learning itself.

4. Textbooks are inadequate in quality and many students study only the notes they have taken during their lessons.

5. In general, secondary school science teachers are other than first-rate students themselves, and their own understanding of the modern sciences is limited, as is their conception of the art of teaching or of science as a means of inquiry.

The Institutes programme was necessarily designed to meet the situation in all its aspects The Institutes programme is not only producing a geographically distributed cadre of informed teachers demanding change, but is also involving college scientists and the university prestige in a demand for change in secondary school science teaching.

In this respect the Science Institutes programme has met with success in this country The materials are scientifically modern and accurate; they emphasize the conceptual bases that give coherence to scientific disciplines; they employ an investigatory approach that is both scientifically and psychologically valid; and they are complete teaching programmes consisting of texts, laboratory manuals, teacher guides, films, and—in the case of physics—specially designed laboratory equipment. Indian scientists, educationists and teachers have been quick to recognize the advantages of these characteristics of the materials used. The participants were expected, when they got back to their classes, to put these methods they have learnt to immediate use within the structures of their present syllabi, examinations and equipment.

Evaluation by Participants

All the participants were asked to answer a questionnaire containing four questions. Below are given some of the responses of the participants from each of the disciplines

Biology. The majority of participants stated that the laboratory work was the most valuable academic programme

presented The next interesting item was group discussion. There was a negative feeling towards lecture presentation at six of the institutes.

Chemistry. The laboratory work along with the pre-laboratory and post-laboratory discussions were valued well above all the other items in the programme. Lectures, films, discussions and demonstrations were next in order. It was felt that school laboratories should be properly equipped, the science laboratories improved, and films and projectors supplied The next suggestion was that the syllabus should be changed and new materials furnished, as also training facilities.

Mathematics. The majority of participants stated that the discussions were most valuable. They appreciated the SMSG programme and the modern approach to algebra and geometry. At six institutes, the participants stated that they were ready to take up the responsibility of starting the new course and teaching the modern concepts in mathematics in their classes provided they were permitted to do so by the school authorities. By and large, the participants requested assistance in the field of books.

Physics. The laboratory experience was voted the most valuable by practically all the participants Discussions and films were also considered very helpful. There was practically unanimous agreement that help with laboratory equipment would be most valuable. Other suggestions pertained to revision of the syllabus and examinations, financial aid, the film projector and readjustment of the time-schedule to permit more laboratory work.

Curriculum Materials Suggested for the 1967 Summer Science Institutes

The BSCS (Yellow Version) should continue to form the basis for biology institutes until indigenous materials are produced. This curriculum should serve only as a prototype for the kinds of material which must be written for the numerous educational communities in India

The CHEMS programme in the summer institutes should be used primarily for teachers of PUC, intermediate, and first year in college. It would be preferred that these teachers have prior permission to use a part or all of CHEMS in their courses the following year or two.

To make use of the PSSC materials in Classes IX, X and XI in Indian schools, considerable adaptation will be required.

The scope of mathematics education in the pre-college experience of the students is of a different order of magnitude than the education in the sciences. Specific training in mathematics permeates every grade of instruction. The training and re-training of mathematics teachers must give proper recognition to these differences.

Those who desire to get more information on the follow-up programme, on the evaluation by American Consultants, Indian staff members and others may get it from the original report which is available at the University Grants Commission, and in the office of the Teachers College, Columbia University team, and with the Agency for International Development of the U.S.A.

News and Notes

SCIENCE AND MATHEMATICS TEACHING PROJECT

TEACHING materials for Class VI in biology, mathematics and physics were completed and sent to press. Similarly, the manuscript of the chemistry textbook for Class VII was also completed and sent to press. As soon as the printed materials were available, they were issued to the students of the experimental schools. Meetings were held with the officers of the Directorate of Education, Delhi, for planning the follow-up of the experimental project, namely, regular visits to the schools by the officers of the Department of Science Education and UNESCO Experts The aim of these visits was to help the teachers to effectively teach the new materials, and to gather the feed-back. Besides these regular visits, the sixty teachers of the experimental schools meet regularly on the last working day of every month for a one-day seminar to discuss problems and exchange ideas.

The science and mathematics class-rooms at the Mother's School (used as a demonstration school) were fully furnished and equipped. The furniture was designed and manufactured in the Central Science Workshop.

The Director of Education convened a meeting of the officers of the Directorate, N.D M.C., and this Department on 24 September 1966 to discuss the possibility of introducing this programme in all the schools of Delhi. A committee has been formed to work out details.

An evaluation team form UNESCO Headquarters at Paris visited the Department and studied the progress of this project. Action is being taken on the suggestions made by this team for future development of this programme.

STUDY GROUPS IN SCIENCE AND MATHEMATICS

MEETINGS of the Study Groups for physics, chemistry, biology and mathematics were convened in the Department during this period. They were attended by the Directors and conveners of the Study Groups and corresponding officers of the Department. Target dates have been fixed for achieving specific objectives for implementing the programmes of the Study Groups. Within the Department the curriculum groups have started carrying out on an analysis of the draft curriculum. Preliminary materials pre-

pared by these curriculum groups have been sent to the conveners and Directors of different subject groups, for study and use.

NATIONAL SCIENCE TALENT SEARCH SCHEME

THE Science Talent Search Scheme has now been rechristened as National Science Talent Search Scheme. It has been extended up to the research degree level The idea of Scientific Olympiads has also been merged into this scheme, providing for the award of scholarship at the close of delta class. Besides the increase in the amount of scholarship at the various levels, reimbursement of tuition fee has also been allowed with effect from July 1966. According to the revised scheme, the awardees will get Rs. 100 per month during the three years of B.Sc; Rs. 250 per month during two years of M.Sc; and Rs. 350 per month during the three- or four-year period of Ph.D. The scholarships will continue in the higher degree courses only if the awardee passes his examinations in the first division.

One-day meetings of representatives of the States' Education Departments were held at Delhi, Calcutta, Bombay and Madras during July 1966 in connection with the next National Science Talent Search Examination held on 1 January 1967.

A publication entitled "Project Report" based on the result of the 1965 examination was brought out

A list of the National Science Talent Search Awardees for 1967 is given on the following pages.

Amarendra Nath Sinha first in the 1967 NSTS examination.

Rekha Devi first among the girl candidates and 14th among all candidates in the 1967 NSTS examination

National Science Talent Search Examination
Awardees for 1967

Rank	*Name of the Candidate*	*State/Territory*
1	2	3
1	Amarendra Nath Sinha	West Bengal
2	Sandesara Niranjan Bhogilal	Gujarat
2	Rajen Pratap	Delhi
4	Kamal Arora	Punjab
5	Kishan Shenoi	Delhi
5	K Muraleedhara Varier	Kerala
7	Amitabha Basu	Delhi
7	Rabikar Chatterjee	West Bengal
9	Ardhendu Sen	Delhi
10	Abhijit Sen	,,
11	Ashoke Kumar Banerjee	West Bengal
11	Amit Mitra	Madras
13	Kumar Srinivas Rao	Delhi
14	Probir Chakraverti	,,
14	Rekha Dev	,,
14	Padmanabhan Kishore	Bihar
17	Anantnarayan Kumar Subramaniam	West Bengal
18	Sangita Suri	Delhi
18	M. Ravi Chandran	,,
18	S Kasturirangan	,,
21	D. Raghunandan	,,
21	Bala Krishna Shetty	West Bengal
23	Jayant Moreshver Manskar	Hariyana
24	Partha Sarathi Sarkar	Delhi
24	Arun Gupta	,,
24	K. V. S. Prasad	Mysore
24	James Jesunatha Das	Kerala
24	Nag Barindra Nath	West Bengal
29	Dilip Ranganathan	Andhra Pradesh
29	Burke Darryl Reginald	West Bengal
31	Ashtekar Abhey Vasant Rao	M.S.
31	Hulikal Ramaiengar Krishnamurthy	Mysore
31	Sandeep Kumar Sengupta	West Bengal
34	Pulak Dutta	,,
34	Shekhar Priydarshee	,,
34	Binay Prasad	Bihar
34	Sudarsana Damodara Prasad	Kerala
34	S Sridhar	,,
34	Deepak Dhar	Uttar Pradesh
40	Bantwal Ramakrishna Rau	Delhi
40	P. Ramani	,,
40	A. Koneti Rao	,,
40	Agarwala Jonathan	West Bengal
40	Abhijit Chatterjee	,,
45	Chatterji Arun Kumar	,,
45	Karthi Keyan Chittayil	Kerala
47	Kamlesh Kar	West Bengal
47	Dpan Kar Sarker	,,
47	K. R Krishna Gandhi	Kerala
47	Shobha Madan	Delhi
47	Loveraj Takru	Uttar Pradesh

1	2	3
52	Ratna Swamy Chandrashekhar	M.S
52	Karuna Shankar Mathur	Delhi
52	Shankar Kumar Shome	West Bengal
52	Ashok Mitra	"
52	Nano Kumar Menon	"
57	Alok Ray	"
57	Madhuri Guha	"
57	Priyadarshan Roy	Uttar Pradesh
57	V. Sundaresan	Delhi
57	Madhur Khanna	Delhi
57	Erach Dorab Tarapore	M.S.
57	Arun Joseph Thangaraj	Madras
64	Dinesh Chand Garg	Delhi
65	Amitava Ray Chaudhuri	West Bengal
65	Raj Kumar Modi	Bihar
65	J. Dinesh Bhat	Kerala
65	Rajiva Ranjan	Uttar Pradesh
65	Rajinder Singh Dhillon	U.T
70	John Varghese	Uttar Pradesh
70	Aditya Narayan	"
70	Banashree Mandal	West Bengal
70	Somanathan K	Kerala
70	K Sesi Bhushan	Delhi
70	Krishna Ram Rao Bhanavar	Madras
70	K. Sriram	"
77	Sreeman Sudipta Kumar Roy	West Bengal
77	Dilip Kumar Shamanna	Mysore
77	Siddhartha Bhowmick	Madras
77	K Raja Ram	Delhi
77	Haresh M Shivdasani	"
82	Satyabarata Misra	Orissa
82	Manish Sarkar	West Bengal
82	Anup Mukerji	Bihar
82	Purnima Pande	Uttar Pradesh
82	T. Ranga Rajan	"
82	Madhuri Bihari	Delhi
82	Lily Dudeja	U T.
83	Subramanian Ananthanarayanan	Madhya Pradesh
90	Kumar Dev Bose	West Bengal
90	Daljit Kaur	Punjab
90	Narendra Dev	Delhi
90	Ashwani Kumar	Delhi
90	Bhaskar Kumar Roy	"
90	Ranjana Vinayek	"
90	Sunita Talwar	"
97	V. Ganesan	West Bengal
97	Parsathi Sinhna	"
97	Ashok Mohan Chakraborty	"
97	Pranab Ranjan Choudhuri	"
97	P Narendra Prasad	Kerala
97	Pankaj Joshi	Uttar Pradesh
97	Dinesh Nettar	Mysore
97	O. K Padmini	Delhi
97	Amrish Kumar Garg	"
97	Sadia Din	"
107	Ayusman Sen	West Bengal

1	2	3
107	Amit Kumar Bose	West Bengal
107	Sanjay Choudhuri	,,
107	Mohan Kumar Phani	,,
107	Barindra Dan	Bihar
107	S. Meenakshi	Uttar Pradesh
107	Syed Faiz Ahmad	Delhi
107	Meena Wij	,,
107	Alawani Ganesh Madhav	M.S.
116	Adarshpal Singh Sethi	West Bengal
116	Amitava Hazra	,,
116	Jaya Sen	,,
116	Arun Bharathuar	Bihar
116	P. Jayanarayanan	Kerala
116	Ashok M. Menon	,,
116	Rajendra Kumar Srivastava	Uttar Pradesh
116	R Radha	Delhi
116	G. R. Rajendran	Delhi
116	K. Shashikala	,,
116	Nigel Barry Pendse	,,
116	Vidushi Saraf	,,
116	K. Ravi Shankar Iyer	Hariyana
116	Susanta Sen	West Bengal
116	Soumen Basak	,,
131	Anjan Sen	.
131	Amlan Kusum Sengupta	,,
131	Souryendra Nath Maitra	,
131	Abhijit Sen	Bihar
131	Deepak Kumar Goyal	Uttar Pradesh
131	P. Vasu	Delhi
131	Madhav Vinayak Marathe	M.S.
131	Rakesh Gandhi	Hariyana
139	Dhanesh Kumar Sukhani	West Bengal
139	Swapan Kumar Saha	,,
139	Tapas Sinha	Bihar
139	Thomas T.	Kerala
139	Udayan Madhukar Paranjpye	Uttar Pradesh
139	B. Krishnarajulu Naidu	Mysore
139	Mukesh Bhanti	Delhi
139	T Prem Kumar	,,
139	Nandini Nityanada	Madras
139	Hemant Krishna Singh	Hariyana
139	Satiesh Chandra Bhargava	Madhya Pradesh
150	R. Rangarajan	Delhi
150	K. Usha	,,
150	Nagesh Sagar	,,
150	Ashok Kumar Singh	,,
150	Rajeev Kumar	,,
150	Mustansir Barma	M.S.
150	Narayanan Chandra Kumar	Madras
150	Trivedi Ajay Indukant	Gujarat
150	Sukhbir Singh	Hariyana
150	Bhupinder Singh	U T.
160	Banerji Lakhindar	West Bengal
160	Bandana Chatterjee	,,
160	Kuruvilla Eapen	Kerala
160	Chitra Venkataraman	Mysore

1	2	3
160	K. S. Anand	Delhi
160	Sunder M Kekre	"
160	Pradeep Narayan Bansod	"
160	Tanganath Desikan	"
160	Ritu Suri	"
160	Kusum Guglani	"
160	V. Sankara Sastry	"
160	Velamur Varadan Anand	M S.
172	Swapan Chattopadhyay	West Bengal
172	Pradip Choudhuri	"
172	Sirajul Hasan	Uttar Pradesh
172	Rakesh Jha	Delhi
172	R. Ramachandran	"
172	Kawal Jeet Singh Sethi	"
172	Aiyagari Sudhakar Rao	"
172	Amita Malik	"
172	Trilochan Singh Anand	U.T.
181	Anil Kumar Singh	Uttar Pradesh
181	Rajiv Kumar Gupta	"
181	Rajiv Sen	"
181	Narendra Nayak	Mysore
181	Amit Kumar Ganguli	Delhi
181	Bappaditya Chakravarty	"
181	K. Sajeeva Thomas	"
181	Vijay Vir Singh Virk	Hariyana
181	Gitesh Ranjan Bhattacharjee	West Bengal
190	K. K. Surendran	Kerala
190	P. Mohana Krishnan	"
190	J. Shashi Kala	Delhi
190	Sushil Rattan Khanna	"
190	Surendra Ponrathnam	"
190	Alok Bhattacharya	"
190	Usha Kaushik	"
190	Asutosh Mathur	M.S
190	Sidharatha Purkayartha	U.T.
190	Bhambri Manju Mohanlal	Gujarat
200	Sobha Nambisan	Delhi
200	Shekhar Chaudhuri	"
200	Raj Kumar Jolly	"
200	Rattan Krishan Sukhani	"
200	Subit Kumar Mandal	West Bengal
200	Eswarahalli Sundarajan Dattatreya	Mysore
200	Sreenivasan Murlidharan	Madras
200	Paramjit Singh Sidhu	Uttar Pradesh
200	Adhikari Mayum Surjalal Sharma	U.T.
200	Shailondra Sahai	Uttar Pradesh
200	B. Ashok	Andhra Pradesh
211	Ajit Singh Hira	Hariyana
211	Vinod Wadhi	Bihar
211	Dolly Chowdhry	Delhi
211	Neera Bhalla	"
211	Narendra Singh Yadav	"
216	Usha Gupta	"
216	Varun Kumar Prasad	"
216	Sheela Roy	"
216	Ramachandran Sreenivasa	"

1	2	3
216	C. R. Rajan	Delhi
216	Rajiv Krishan	,,
216	E. A. Chakachery	West Bengal
216	Prithwish Dutt	,,
216	Debashis Chakraberty	,,
216	Rita Das	,,
216	Krishna Kumar	Andhra Pradesh
216	Ragini Vedantan	Mysore
216	Mohan Menon	,,
216	Vijaya Laxman Deshpande	M.S.
216	Navin Hiranand Makhijani	,,
216	Sudhir Kumar Saxena	Uttar Pradesh
232	Ranjit Kumar Nair	Bihar
232	Kose John	Kerala
232	Arungurdram Krishna Murthi Vijaya Kumar	Madras
232	Raj Kumar	Punjab
232	Om Parkash Gupta	Uttar Pradesh
232	Ashok Arora	,,
232	Salit Banerji	West Bengal
232	Swapan Kumar Bose	,,
232	Pranab Roy	,,
232	Prabhat Narayan Shukla	,,
232	Apji Suchet Chaudhuri	,,
232	Sushil Duggal	Delhi
232	Krishna Mazumdar	,,
232	Pravin Kumar	,,
246	Amar Kumar	,,
246	Manoj Shukla	,,
246	N. Arjun	,,
246	Swapan Kumar Chatterjee	West Bengal
246	Asim Ranjan Pati	,,
246	Ranjit Chatterjee	,,
246	Raj Bhuptani	Bihar
246	Ashfaq H. Arastu	Andhra Pradesh
246	Neithalath Mohan Kumar	Kerala
246	C. P. Mammoy	,,
246	Raman Srivastava	Uttar Pradesh
246	R Ravindran	Mysore
246	Wahiduddin Ahmad	Assam
246	Dinesh Kumar	Hariyana
246	V. Kumaraswami	Madras
261	Deva Prasad Saha	West Bengal
261	P. P. Sreedharan Namboodri	Kerala
261	Rakesh Jindal	Uttar Pradesh
261	Arun Kumar Grover	,,
261	Anil Banerji	U.T.
261	Neelamegam Sundarajan	M.S.
261	Roshen Onden	,,
261	Vaishna Jaggi	Delhi
261	Renu Taparia	,,
261	Sumitra Basu	,,
261	Usha Sharma	,,
261	Bina Aggarwal	,,
261	R Latha	,,
274	Jitendra Nath Budhraja	,,
274	Anil Chatterji	,,

1	2	3
274	Arindam Sen	Delhi
274	Geta Kiron Bhalla	"
274	Poonam Nanda	"
274	Shobha Rajan	"
274	Chanchalendu Banerjee	"
274	Ashok Mehandru	"
274	V. G. Geetha	"
274	Arindam Banerjee	M.S.
274	Seshadri M. Prasad	Mysore
274	Ashok Benegal	Uttar Pradesh
274	Mennakshi Avasthi	"
274	T K. Prakash	Kerala
274	Ananda Vally L.	"
274	Manoranjan Prasad	Bihar
274	Ashok Kumar Sen	West Bengal
274	Ranabrata Sen	"
274	Gadre Deepak	"
274	Ashok Kumar Chowdhury	"
294	Manoj Kumar Datta	"
294	Utpal Sanyal	"
294	Parbati Bhattacharya	"
294	Prithish Ganguly	"
294	Tamirisa Venkata Srinivasa Charyulu	Andhra Pradesh
294	Kum Kum Kanwar	Uttar Pradesh
294	R. Ramani	Madras
294	Shaikh Rashid Ahmed Mohamed Usman	M.S
294	Shyam Kumar Gupta	Delhi
294	Arvind Mangla	"
294	Santosh Kumari	"
294	Ravindar Khanna	"
294	V. Sridhar	"
307	Nirmal Kaur	"
307	Sandhya Misra	"
307	Vindu Mittal	"
307	M Seshadri	"
307	K. K. Lalitha	Delhi
307	Vivek Vishwanath Rane	Mysore
307	Hampapuram Kasturi Krishna Priyan	"
307	Santosh Kumar Rao	Uttar Pradesh
307	K. Sohbini S.	Kerala
307	Biswajit Banerjee	Bihar
307	Chitra Durga Narasinha Murthy	West Bengal
307	Anjan Kumar Das	"
307	Soumya Chakravarti	"
307	Santanu Dutta	"
307	Vijay Kumar Dattatraya Rao Toley	M.S.
307	Nandini Katre	"
307	P. N. Vijay (Pattamadai Natraja Sarma)	Madras
307	R. Jaya Mohan Pillai	"
307	K. Rupa Sirohi	Rajasthan
307	Inder Jit Singh	Madhya Pradesh
327	Ramanuj Sharan	Bihar
327	Narayanasami Sathyamoorthy	Madras
327	Om Prakash Panwar	Haryana
327	Ramesh Sampath	Uttar Pradesh
327	Deepak Bhatia	"

1	2	3
327	Pradeep Kaur	Himachal Pradesh
327	Revis Angelo Coutinho	M S
327	Kothari Surajmal Chandmal	,,
327	Swoyam Prakash Rout	Orissa
327	Sugata Ray	West Bengal
327	Arun Prasad Chatterjee	,,
327	Alokenath Bhattacharyya	,,
327	S. Rangarajan	Delhi
327	Akhilesh Bansal	Delhi
327	R. Shantha	,,
327	Yudhisthir Kumar	,,
327	Jaishree Banerjee	,,
327	Sabir M.	Kerala
327	Jese P. Panakkal	,,
346	Om Parkash Sharma	Delhi
346	Gavinder Kaur Mujral	,,
346	Madhu Agarwal	,,
346	Rakesh Bhalla	,,
346	Thimiri Perumal Rajmanohar	,,
346	N. Ramesh	,,
346	V. Mahalakshmi	,,
346	Meduri Venkata Bhaskara Satyanarayana Murthy	Andhra Pradesh
346	S Jayaraman	Bihar
346	Falgnni Kumar Sen	Gujarat
346	Thadathil Mathews George	Kerala
346	George Cyriae	,,
346	Ralph Victor D'rozario	,,
346	Arunabha Datta	Assam
346	Kursheed Begum Fqkkir Mohamed	Madras
346	K. Shankar Rani	Uttar Pradesh
346	Dixit Ajit Suresh Lal	M S.
346	Neela Madhukar Kher	,,
346	Satuinder Dhillan	,,
346	Hrishi Kesh Das	West Bengal
346	Anjana Basak	,,

Books for Your Science Library

Predicting the Human Scene Is Not So Easy

The World in 1984-Vol. II.
New Scientist Series, Penguin Books, Ltd., Harmondsworth, 1965

THE first volume of this collection of *New Scientist* essays, reviewed *in Spectrum 12,* dealt mainly with pure science and technology. The result was a preview of 1984, broadly optimistic in tone, with new discoveries and techniques solving many outstanding problems.

Volume II is more concerned with sociology, economics, education, health and international relations—and here the view of 1984 is much more uncertain.

When writers turn from discoveries and inventions to human affairs, it is clear that they feel on much less certain ground. There are, though, two broad areas of agreement

The first is very simple: most writers assume, either explicitly or implicitly, that there will be no full-scale thermonuclear war between now and 1984. If there were, they imply, there would be no recognizable world left to write about.

It is perhaps encouraging that the contributors generally seem to believe that we have a very good chance of avoiding this ultimate catastrophe.

The other looming problem, to which many writers refer, is the population explosion, which is likely to mean that there will be 50 to 60 per cent more people in the world in 1984 than there are today. Furthermore, expectation of life will have increased, dramatically in some areas.

Even today, over half the population of Venezuela, for example, is under 19 years old—a direct result of modern hygiene and medicine. But by 1984 there will also be a much larger population of old people to care for.

The problems of feeding this vast population have received much attention and publicity. But several of the essays in this collection emphasize some other formidable problems, notably the likely growth of vast sprawling cities, which will be exceedingly difficult to manage and maintain.

Ruth Glass, of University College, London, predicts that by 1984 there may be cities which would make present-day London, Tokyo or New York look puny. Calcutta, for example, may have a population of up to 40,000,000. Since replanning and reconstruction are

very unlikely to keep pace with this growth, the contrasts between old and new quarters, between slums and affluent districts, may well be enhanced—which could aggravate social unrest. "There will be turmoil in and around many cities of the world even before 1984," Mrs. Glass says.

Coupled with the urban explosion, many experts foresee an education explosion. Mr. Rene Maheu, Director-General of the United Nations Educational Scientific and Cultural Organization (UNESCO), believes that by 1984, all children will go to school, if only for four to six years. Illiteracy will have receded, and will remain mainly among the old. But education will have expanded dramatically in more advanced countries, too, which could perpetuate the "education gap".

Automation, and rapid social and technological change, will mean that education must gradually become something which continues all through life Lord Bowden, now Minister of State in Britain's Department of Education and Science, says that unless we can make provision "on an enormous scale" for continuous adult re-education, Britain alone could by 1984 have 2,000,000 men unemployed, for want of the right knowledge and skills.

But if these education problems are successfully tackled, it will be possible to exploit automation to the full—which in turn could mean much more leisure. Joan Littlewood, the well-known artistic director of London's Theatre Workshop, describes her "laboratory of fun" to meet 1984 leisure needs.

There will be, for example, the "music area" offering free instruction and recordings on any instrument, as well as record collections, concerts and jazz festivals. There will be an acting area, where people from shops and offices "will be able to re-enact incidents from their own experience in burlesque, mime and gossip". A "plastic area" will offer paint, clay, stone, textiles and other materials for "uninhibited dabbling".

The site will be in London, near main roads and stations, the buildings highly flexible and mainly temporary (some will be inflatable 'igloos'), making rapid changes to meet possible new needs.

A much more sombre view is taken by Sir Herbert Read, who argues that the surfeit of ready-made entertainment will make real art wither, and produce empty lives in which leisure is a "problem" rather than an opportunity and a blessing.

He foresees nationalized gambling becoming the greatest form of revenue, and the virtual disappearance of books and poetry, the only writers being television script producers. "There will be lights everywhere", he predicts, "except in the mind of man".

In a somewhat similar, but less gloomy view, Richard Hoggart argues that as technology advances, the values and experiences mediated by the humanities will become increasingly precious and in need of support. Otherwise, he foresees language coming to be used mainly for "manipulation" (by advertising or other interests) or for commonplaces, while mass production in the arts could tend to "bureaucratize taste, ideas and imagination, to thin out the sense of life".

Another contributor, Lord Brain, says that great advances in psychology and

physiology could have a major impact on the treatment of mental disease—but at the same time, various new drugs may be used "to enhance and diversify experience". But the social problems of addiction will grow and "will have to be faced long before 1984".

In medicine, Sir Charles Dodds predicts that the two overriding current problems, cancer and heart diseases, may well have been conquered, and research will focus increasingly on the problems of ageing. It may well become possible to enable the majority to grow old without the distressing degeneration of many faculties and functions which now makes the geriatric wards of hospitals such distressing places.

"The great luxuries will be pure water from a spring, plants and animals carefully raised by the consumer himself in the absence of chemical contamination, fish caught in the high seas away from the coast."

More cheerfully, Professor Thring, of Queen Mary College, London, foresees the possibility of advanced robots relieving the housewife of much drudgery. Ten years' intensive development and the expenditure of £1 000,000 should produce a machine able to find its way about the house, make beds, wash up, clean and so on.

This will be especially welcome if as Dr. Michael Young predicts, family life grows in social importance. It will become easier, Dr. Young says, for families to take in elderly parents and look after them, while the growing complexity and impersonality of the surrounding world will make home seem "more intimate and cosy".

In contrast, government will come increasingly to depend on computers and specialized experts, according to Professor Asa Briggs, of the University of Sussex 'Back-room boys' who have done much detailed work on long-range plans will acquire great power—but the techniques of explaining and presenting such plans will become correspondingly more important.

The facts of economic life and of military power will narrow the room to manoeuvre in national politics and policies, and countries will increasingly have to practise "unconditional surrender to facts", says Professor Briggs.

But Dr. V. K. Zworykin, of the R.C A. laboratories in America, predicts that modern electronic techniques could have far-reaching effects on the democratic process.

In particular, he has worked out a scheme for adapting domestic telephones for mass voting. A government could then hold national plebiscites on any issue at short notice. The results of telephone voting would be processed by computer and could be known in an hour or two.

Thus, governments could consult the people directly over a vast variety of issues. This, Dr. Zworykin claims, would create "a better informed and more vitally interested citizenry".

To sum up, the whole series reveals considerable unanimity about the likely trends in science and technology. In particular, there is agreement that the most important discoveries are likely to be made in biology and medicine There is also general agreement that the pace of change—and, in particular, the population explosion—will test our adaptability, humanity and resourcefulness to the utmost. But it is here, too,

that the optimists and pessimists part company.

In general, the scientists have confidence that society will be able to digest and exploit the results of their researches for the general human benefit. But sociologists, economists—and a proportion of scientists themselves—are deeply concerned that we are getting out of our depth; that we shall not be able to adapt our cities, our agriculture, our social habits and practices fast enough to prevent much misery and turmoil arising by 1984.

But perhaps the most heartening feature of the series is that no writer expects total thermonuclear disaster; and no one predicts that George Orwell's nightmarish totalitarianism will actually be realized. And the very fact that so many distinguished people are so vividly aware of the problems confronting us is, perhaps, the best hope that they will be successfully tackled.

Courtesy, *Spectrum* 13, June 1963

India's Action Programme for Improvement of School Biology

B. M. Johri
Manohar Lal

FOR the past several years, educationists in India have strongly felt the urgency of the need to bring about an all-round improvement in the teaching of science in schools. This consciousness has resulted in, besides other measures, the establishment of a Department of Science Education by the National Council of Educational Research and Training. This Department has launched many schemes for the improvement of biology teaching. The activities of the Biological Science Curriculum Study Group (BSCS) of the U.S.A. have also given a great incentive to the School Biology Programme. An analysis of the existing problems and the reform work undertaken in India was reported at the First Asian Regional Conference on School Biology held at Manila from 4 to 10 December 1966. This article describes some of the fruitful projects that have been launched for the improvement of biology education in Indian schools; these schemes have been under way for quite some time, and some have been initiated after the publication of the recommendations of the First Asian Regional Conference on School Biology.

Post-graduate Diploma Course for Junior Science Teachers

With the object of overcoming the the acute shortage of well-trained science teachers for higher secondary classes, the Education Department of the Delhi State has started a diploma course for junior science teachers. This course is being conducted by the University of Delhi. The junior teachers are science graduates who teach only the lower secondary classes After completing this, diploma course, these teachers would be entitled to teach higher secondary classes.

This course is an in-service teacher training programme of two years' duration. Presently there are two separate courses in biology, and the candidates are allowed to take either botany or zoology. This traditional splitting of the subject is not desirable academically, but it had to be adopted, for the time being, due to organizational difficulties. Classes are held daily during the summer vacation (15 May to 6 July) and on week-ends when the schools are in session.

These courses are aimed at strengthening the knowledge of junior (graduate) science teachers so that they

may adequately meet the demands of a modern science curriculum. The course content has been especially designed to bring up to date, and build upon, the teacher's scientific background, and to prepare him to become an effective, imaginative and resourceful teacher for higher secondary classes. The candidates are required to offer, besides other topics (out of a total of six papers) one full paper on Methodology of and Aids to Biology Teaching.

The planners of this scheme hope that it will not only make available many more trained science teachers but will also afford prospects for improvement of the status of junior teachers.

Textbook and Curriculum Programme

The National Council of Educational Research and Training has now released all the seven parts of *Biology—A Textbook for Higher Secondary Schools.* This is the first modern book on school biology produced in India. It has been prepared by a panel of Indian biologists under the chairmanship of the late Professor P. Maheshwari. The drafts of a number of chapters of this book were reviewed by several foreign experts and school teachers, and the book was finally edited and illustrated jointly by Professor Maheshwari and his pupil, Dr. Manohar Lal, at the Department of Botany, University of Delhi.

The book has seven more or less independent sections. In the first section, the student is introduced to the subject-matter of science, particularly biology, and the characteristics of living matter. A glimpse of the variety of plant and animal life prepares the student for a more detailed study of these forms in the second and third sections. The fourth section treats in a simple way the main physiological processes in animals and plants. The fifth section is devoted to a comparative account of the different modes of reproduction in the plant and animal kingdoms. Heredity, evolution and ecology form the sixth section of the book. The epilogue to the book covers topics like human disease, interdependence of plants and animals, and the role of biology in human welfare. It must be admitted that in the initial stages of the break through from the traditional, old-fashioned curricula, an abrupt change to the most modern practices would have been unacceptable, especially to the teachers. The book has therefore adopted, for the time being, a modernized traditional approach to the subject, and represents the first stage of the change-over process. It admirably paves the way for individual biologists and agencies for preparing other books which could be more varied and modern in approach.

The schools under the Central Board of Secondary Education in Delhi and in some other states have adopted this book. The reports from the teachers and other concerned with biology education are very encouraging. Many valuable comments have been received and these will be used for the improvement of the present version. A revised edition of the book in the light of comments received is envisaged in a couple of years.

It is encouraging to note that the National Council of Educational Research and Training has now set up five different Study Groups for biology, functioning in the universities of Delhi,

Punjab (Chandigarh), Calcutta, Osmania (Hyderabad) and Madras. The members of these Study Groups have differing backgrounds and are free to adopt the approach that they can handle best. They will prepare curricula and textbooks for school biology at two levels — the first level comprising Classes V, VI and VII, and the second level comprising Classes VIII, IX and X.

BSCS Adaptation Programme

In the meantime, the National Council was authorized to print a limited number of non-classroom copies of the BSCS biology textbook, *Biological Science: An Enquiry into Life*. The related *Laboratory Guide and Teacher's Manual* were also made available. These books have played a key role in the Indian Biology Summer Institutes. The institute programmes have emphasized the use of the laboratory in teaching biology as a science. Because of their different biotic and cultural background, the BSCS books have had only a limited utility. This difficulty will be overcome when the modified Indian adaptation of BSCS books is issued shortly. The work on this project was started a couple of years ago by a team of Indian biologists and secondary school teachers under the general direction of Dr. S. Krishnaswami, Professor of Zoology at Madurai University. Two American experts, Walter Auffenberg and Manert Kennedy, assisted the team during the summer of 1967. The first draft of the adaptation materials is ready and will be tested in some selected schools before a final edition is published.

U.S. Collaboration with India for Improvement of Science Education

In June 1966, Indian representatives of the University Grants Commission, the National Council of Educational Research and Training, the Association of Principals of Technical Institutions, and several divisions of the U.S. National Science Foundation, as well as leading American and Indian scientists jointly developed the broad outlines of a national programme for the improvement of science education in India. A special agreement was signed between the Government of India and USAID (India) for pooling efforts to undertake a large scale Science Education Improvement Project. From the Indian side, this project will be carried out by the newly established National Council of Science Education (NCSE), the governing body of which consists of distinguished scientists and educationists. The U.S. collaboration will be provided through the NSF Science Liaison Staff in India. The basic purpose of this project is to establish the means for continued improvement of science education in India The U.S. participation will continue, according to the present agreement, up to 1971. By this time the NCSE would have sufficient staff and also appropriate procedures to evaluate the weaknesses and strengths of the national programme for improving science education without external help. The main targets of this programme are outlined below.

The Development of Instructional Materials. It is proposed to undertake adaptation of appropriate materials (textbooks, laboratory manuals, teacher's guides, etc.) developed in the

U.S.A., plus the production of new materials to meet specific Indian situations. An important part of this programme will be the production of local language versions of a number of books. The indigenous manufacture of laboratory equipment and the production of textbooks and other teaching materials will be promoted.

The Cooperative University-College-School Programme. In this project the universities will provide services to a number of high schools for improvement of teacher training courses, curriculum development, syllabus and examinations improvement, and for assistance in the design, acquisition and utilization of modern teaching aids and materials, and in school library development. This cooperative project will be tried in one or two suitable places on an experimental basis.

The College Faculty Development Programme. Under this programme the affiliating universities would be made to take care of their respective colleges—which ultimately provide the teachers for schools. The programme will include in-service and short-term training of college teachers, development of courses and curricula, equipping of college laboratories, and expansion of departmental libraries.

Short-term Institutes. The NCSE will continue the short-term institutes (teacher training programme) for Indian school, college and university teachers of science. This programme, initiated in 1963, has been very well received by the Government of India, the educational authorities, the University Grants Commission, and the universities. The teachers participating in these programmes have also been very enthusiastic. The Council will go ahead with augmenting and improving the programme of short term institutes to make them part of an integrated systematic scheme for national development.

Programme Development and Special Project Hand in hand with the above projects, the NCSE will undertake experimentation to find such approaches which in the long run will be more useful in India. Such a programme is considered vital for the growth of any institution.

Impact of USAID Collaboration

Although many of the projects outlined above are yet to reach the take-off stage, U.S. participation in the efforts of various Indian educational agencies has already started showing encouraging results.

During the past five years, some 12,000 Indian college and school teachers have undergone training in 352 summer institutes. This body of teachers, whose interest and enthusiasm have been excited by exposure to new methods and materials for science teaching, provides a nucleus of teachers who have been prepared to be favourably disposed towards continuing improvement in science education.

A new journal, *Science Newsletter*, devoted to the improvement of science education in India, has been brought out. To give it a good start, the USAID (India) has undertaken to subsidize the first year's cost of production and mailing expenses. By the end of this period the journal may have enough subscribers to run on its own.

Thus science education in India is marching ahead and with each year the pace will have to be even faster.

Evaluation Methods for Constant Checking of Pupils' Knowledge

V. A. GLUSHENKOV
K. S. BHANDARI

WITH the help of UNESCO experts, the Department of Science Education of the National Council of Educational Research and Training has started an experimental project for teaching biology, physics and mathematics as separate disciplines in Classes VI to VIII, and chemistry also in Classes VII and VIII, in thirty schools of Delhi. This scheme is likely to be extended so as to include 25 per cent of the schools in Delhi and in the different States of India from 1967. The two main features of the project are the demonstrational-cum-experimental method of teaching and the system of evaluation—the method of constantly checking pupils' knowledge. This article relates to the latter feature of this project.

New Concept of Evaluation

According to the Report of the Education Commission (1966), evaluation is a continuous process which determines the degree or the extent to which educational objectives are attained. It forms an integral part of total education. It exercises a great influence on pupils' study habits and teachers' methods of instruction and thereby helps not only to measure educational achievements but also to improve them. The techniques of evaluation are means of collecting evidence about the student's development in the desired directions. For this purpose, the techniques that are to be used should be reliable, objective, and practicable.

In India, the common method, or the only method of evaluation is the written examination. But there are several aspects of the student's growth that cannot be measured by the written examination only. So other methods such as observational techniques, oral checking, etc., have to be devised for collecting evidence for the purpose, and these methods should be improved in such a way that they become reliable instruments for assessing the student's performance and educational achievements.

To supplement the results of the external examination, most of the educational boards introduced the system

of internal assessment. But experience has shown that the internal assessment system has not been a very happy choice. The reasons for this are many, the most important one being that the teachers are not equipped with proper evaluation techniques. It has been suggested that internal assessment should be abandoned if it cannot be properly done. However, the Education Commission is of the view that this system has to continue and its importance has to be increasingly emphasized.

If this is to be so, some sound methods, by applying which a teacher may be able to assess not only the day-to-day progress of pupils' knowledge but also to judge the effectiveness of his teaching, are to be devised. One method of assessing pupils' knowledge called 'Constant checking of the pupils' knowledge' is presented here. This method is comprehensive and can evaluate all those aspects of a student's growth that are measured by external examinations and also such aspects as scientific skills, attitudes and interests, which cannot be assessed by written examinations. This method is to be used mainly for improving the student's achievement in addition to measuring the level reached.

Constant Checking of Pupils' Knowledge (Evaluation)

The Experimental Project aims to fulfill the following objectives of science teaching:

1. To give to the pupils a systematized knowledge of the fundamentals of science and to ensure an understanding of scientific facts in the light of leading scientific theories.
2. To develop the ability to apply the scientific knowledge gained in solving new problems.
3. To develop scientific skills

In order to find out the extent of the scientific knowledge gained by the pupils and the progress made in the development of abilities and skills, the teacher will have to check constantly the effect of his teaching upon the pupils. The technique of evaluation, i.e., constant checking of pupils' knowledge, should not only judge pupils' knowledge, ability and skills but also should help us to know what methods and materials are to be employed to improve the teaching-learning situations.

The constant checking of pupils' achievement is a very important aspect of educational work in the school. It should be used as a teaching tool and should permeate all the stages of teaching. With its help a teacher finds the level and soundness of systematic comprehension of knowledge, of development of skills, and of the pupils' ability to independently apply the knowledge and skills acquired to solve practical problems. Besides this, constant checking is used for recapitulating pupils' knowledge and skills, correcting their mistakes, and broadening, deepening and generalizing their knowledge.

The checking of pupils' progress trains them to work systematically and apprehend correctly, and not to be afraid of difficulties. It helps in finding ways to overcome the difficulties. In constant checking, a teacher should evaluate pupils' knowledge of each significant theme or part of the course.

The Department of Science Educa-

tion is of the view that the promotion of pupils from one class to another should be made on the basis of the record of the constant checking maintained by the teacher. But in view of the prevailing system of examinations, which cannot be changed easily, the Department recommends that for the time being equal weightage should be given to the record of the constant checking and to the annual written examination. This will not only motivate the pupils to work hard and to come prepared with the lessons but will also stimulate them to learn more and more It will also help the pupils to develop regular habits of study and thus achieve desirable goals of education.

Methods of Checking Pupils' Knowledge and Skills

The most significant methods are:

A. Oral checking
B. Written checking
C. Checking with the help of experiments done by pupils
D. Checking with the help of a combination of methods A and C.

(A) Oral Checking. The teacher as a rule should resort to oral checking before introducing new material to the class. During the lesson he should especially use evaluation, generalization and recapitulation of pupils' knowledge. All these help the teacher to check the assimilation of previous material. Thus, correlation between the previous and present material is established.

In the course of oral checking, a teacher asks questions and suggests problems of various types and a theme for narrating.

To involve all the pupils in the work, the teacher should first ask a question and then, after a short pause, name a pupil to answer it. After the pupil has answered, the teacher should ask other pupils to correct the mistakes, if any, or to complete the answer.

While asking questions, the teacher should always keep in mind the following:

1. The requirements of the syllabus, i.e., the objectives to be achieved.
2. Questions should be formulated in simple form; the terminology used should be familiar to the pupils
3. Questions must be constructed in a specific manner and not in general terms.

During botany lessons in Class VI, simple questions like the following should be asked: What are the substances absorbed by plants from the soil? What plant organs absorb nutritious substances from the soil? What are the fertilizers applied? Name some organic fertilizers. Why do we loosen the surface soil of a plot?

Questions that require quick thinking are very useful. In Class VI, in the theme 'Seed Structure' pupils are asked to indicate the 'similarities and differences between a wheat seed and a bean seed'. In the theme 'Parallelogram,' pupils are asked to indicate the common and distinctive properties of different types of parallelograms.

In the lessons on mathematics, physics and chemistry, pupils are asked to work out problems of practical interest. For example, in Class IX, in the lessons on Rectilinear Motion in physics, the teacher may give the following problem: 'A car moves for 30 minutes at

a velocity of 40 km/h, and for 2 hours at a velocity of 50 km/h. What is the average velocity of the car?' In a mathematics lesson in Class VI, he may ask. 'A boy made a frame in a workshop. To make sure that it was made properly he checked the three angles as in the figure (Figure 1). They were proved to be right angles Now prove that the opposite sides are parallel.'

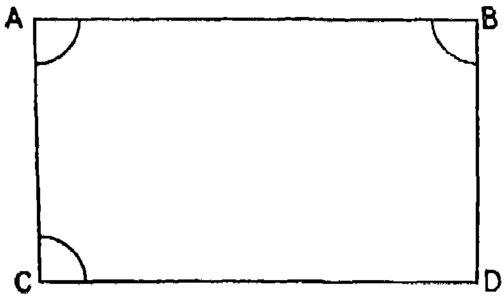


Fig. 1.

Sometimes the teacher may ask simple questions, but they should be such that to answer them the pupil would not only have to know the theorems, but also how to use them in unusual conditions, e.g., 'Give one of the conditions necessary to prove that two given straight lines are not parallel.'

Practical work in mathematics is introduced to establish sound links between the school mathematics course and everyday life and to develop in the children some skills which will be necessary for their future work. The following are some problems of this kind.

Class V. Calculate the yield of potato crop from the school experimental plot.

Class VI. Make a plan of the school and the school experimental plot.

Class VII. Calculate the working time necessary for preparing the school experimental plot to raise a certain crop.

Simultaneously with questions and problems, the teacher may ask the pupils to narrate certain important and specific themes with a view to developing logical thinking and expression in the pupils. This is usually practised in senior classes but sometimes even in Classes V to VII a teacher may use this method if he is convinced the capabilities of his pupils will enable them to cope with questions of this kind. Some examples are ·

Class VI Physics. Archimedes' Principle as applied to gases

Class VII Chemistry. Burning of substances in oxygen

Class VIII Algebra. Properties of equations

Class IX Chemistry. Chemical properties of chlorine, etc.

Narration of the given theme by the pupils helps the teacher to judge their ability to work logically, concretely and soundly. Before starting the narration the pupil should map out the plan of the answer and sketch the necessary equipment (in chemistry, physics, biology) and design (in mathematics) on the blackboard. While narrating 'The types of roots' in a lesson in botany in Class VI, the pupil should sketch on the blackboard a schematic picture of a root:

Adventitious roots
Lateral roots
Main root.

It should be mentioned that in junior classes the teacher may help the pupils while they answer questions of this kind, and draw up a plan of narration.

In a chemistry lesson in Class IX,

while narrating 'The manufacture of hydrochloric acid,' the pupil should sketch on the blackboard a scheme of the plant (or he may use a model).

Pupils must also be able to work out equations of chemical reactions, assemble devices, and demonstrate experiments of short duration.

For example, in a lesson in botany a pupil, while narrating the theme of evolution of oxygen by plants in the presence of sunlight, should draw on the blackboard the necessary sketch.

Experiments demonstrated by pupils in the course of their retelling need not necessarily be completed if they are lengthy or if their results do not present any interest. For example, one need not complete an experiment on filtering liquids, if the teacher, by watching the start of the experiment, is convinced about the pupil's ability to conduct the experiment and of his knowledge of the topic.

Acquisition of knowledge and skills is closely connected with repeated demonstrations, the use of visual aids and apparatus, and with experiments already performed during previous lessons.

As stated earlier, the oral checking of pupils' knowledge and skills should occupy a certain time (as a rule one-third of a lesson). To cover more pupils during the same period of time, the teacher may attempt to question simultaneously three or four pupils. The first and second pupils may get certain themes for retelling; the third pupil, a calculation or a quantitative problem; and the fourth, some experimental task, i.e., to conduct a certain experiment.

While these pupils are preparing to answer, the teacher may ask two or three more pupils from the rest of the class to answer other questions. Thus, applying these methods, the teacher can ask questions within a short period of time from quite a number of pupils.

The effectiveness of such checking of pupils' achievements depends on *a teacher's preparation for the lesson.* This includes also the preparation of questions that envisage the formulating of themes for narration, selection and composition of problems, and preparation of lists of pupils to be questioned. Before the lesson, it is necessary to place on the demonstration table all the apparatus, and the various parts needed to assemble it, etc., which are to be used for the explanation of the themes to be asked. The process of oral questioning should be advantageously used by the teacher to evaluate his own teaching and to effect improvements in future lessons.

(B) Written Checking. Written checking of pupils' knowledge helps the teacher to find out within a short time the pupils' comprehension and mastery over the whole of the material taught.

There exist several ways of carrying out a written check of pupils' knowledge. Some of them are:

(a) Control (checking) work on the previous material that may last for one period.

(b) Short written work (lasting not more than 15 minutes) on different problems during the course of a lesson.

(c) Written homework.

(a) *Control work* lasting for one period (or two periods in senior classes) is conducted after a chapter has been studied. The most responsible part in control work is the proper selection of topics for composing the problems and

exercises. While framing problems and questions, the following points are to be kept in view:

(i) The control work should comprise problems and exercises on the new and the most important material taught in the previous chapter.

(ii) The quantity of the work assigned should be strictly in proportion to the time allotted.

(iii) Problems and exercises should be chosen in two or four variants to ensure independent work by the pupils.

As a rule, mathematics teachers may include in the test papers even more variants.

Let us take as an example the contents of a piece of control work in chemistry for Class IX on the theme 'Oxides, bases, acids and salts'.

Variant I (A set of questions)

1 Write down the equations of the reactions between the following substances:

(i) Calcium oxide and nitric acid
(ii) Carbon dioxide and barium hydroxide
(iii) Magnesium oxide and sulphur trioxide.

2. Write down the formulae and the names of:

(ii) Oxy-acids
(ii) non-Oxy-acids.

3. Write down a reaction for the following transformations:

$$Mg \longrightarrow MgO \longrightarrow MgSO_4 \longrightarrow Mg(OH)_2$$

4. Convert the following schemes into equations of reactions reaching completion:

$$AgNO_3 + ? \longrightarrow KNO_3 + ?$$
$$CuSO_4 + ? \longrightarrow Na_2SO_4 + ?$$

Variant II

1. Write down the equation of reactions between the following substances.

(i) magnesium sulphate and barium cloride
(ii) ferric chloride and potassium hydroxide
(iii) barium nitrate and sulphuric acid.

Do the above reactions reach completion? If so, why?

2. Write down the formulae and names of oxides of the following:

(i) bivalent iron
(ii) trivalent iron
(iii) tetravalent sulphur
(iv) monovalent sodium.

Indicate which of the oxides are basic and which are acidic.

3. Write down the equations of reactions for the following transformations:

$$Zn \longrightarrow ZnO \longrightarrow ZnCl_2 \longrightarrow Zn(OH)_2$$

4. Convert the following schemes into equations of reactions reaching completion:

$$BaCl_2 + ? \longrightarrow 2HCl + ?$$
$$Al_2(SO_4)_3 + ? \longrightarrow 2Al(OH)_3 + ?$$

Note that the above two variants do not contain calculation problems. After the teaching of one chapter has been completed, one more control assignment with calculation problems may be framed.

Here is a specimen of control work in physics in Class X on the theme 'Electric capacity'.

1. The earth and the conducting strata of the atmosphere form a peculiar condenser. From observations, the average voltage of the electric field of the earth near its upper layers is equal to 1v/cm. Suppose that the electric charge of the earth is evenly spread over the whole surface of the earth, and find out its amount.

2. What are the voltage and potential of an electric field? What is the relation between the *difference of potential* and the voltage of an electric field?

Specimens of Control Work in Mathematics

Class IV

1. A cooperative store sent to a canning factory 11 tons 975 kg of fruits and to a shop 3 tons 950 kg less. 3/5 of all the fruits were apples

How many boxes are required for packing all the apples, if one box can hold 30 kg of apples?

2. Draw a rectangle, the length of which is 1 dm 2 cm, and the breadth 3 cm less than its length. Calculate the perimeter and area of the rectangle.

Class VI

1. Solve the equation:

$(3.2-2a)\ 2.5a+a\ (5a-0.5)=1.5$

2. Subract the product $6.4^2b^2\ (2.5ab-5b+1)$ from the product $8a^2\ b\,(2ab^2+b-1)$. Calculate the numerical value of the result, $a=0.25$; $b=-1$

3. Write down a general formula of a number having x hundreds, y tens and z units.

Class IX

1. At what value of m will the system of linear equations

$$(m-1)\ x-2y=2m-3$$
$$-6x+3\ (m-2)y=10.5$$

have:

i) one solution

ii) an infinite number of solutions

iii) no solution at all.

In order to save time, it is advisable that copies of the work should be distributed among pupils.

The written control work should be corrected immediately and discussed in the class in the next lesson. This will ensure that the pupils have understood their mistakes The analysis of the control work after a long gap becomes ineffective, because pupils forget the content and lose interest in it.

While analysing the results, the teacher should first give a general analysis, then point out the best work, and at the end indicate some mistakes and ways of correcting them.

One of the first steps to be taken for removing shortcomings in the knowledge of each pupil should lie in guaranteeing independent solving of exercises in the post-control work period.

(b) *Short written work* or short control work is given to check the pupils' mastery of the problems studied and to select some additional pedagogic measures to develop pupils' knowledge and skills. For example, in Class VII, after the pupils' initial acquaintance with valency, and with working out of formulae by valency and finding the valency of elements in combinations from their formulae, the teacher should give a short 15-minute item of written control work at the end of the lesson. This work may contain the following questions:

1. Write down the formulae of the oxides of the following: potassium, magnesium, aluminium, sodium and calcium.

2. Find the valency of the elements in the following combinations:

H_2S, CH_4, Fe_2O_3, SO_2, BaO.

Specimen Work in Mathematics for Class VI

1. The isosceles triangle ABC has the

base AC. The congruent segments AM/CN are marked on its sides.

Find CM, if AN = 8 cm.

2. Draw an isosceles triangle, draw altitudes from the vertices of its acute angles and a median from the vertex of the triangle.

Such problems may be given in two to four variants.

(c) *Checking of written home work.* Checking of written homework is carried out by various methods. The teacher goes to the pupils' desks and looks through their note-books. Simultaneously one of the pupils' desks and looks through their note-books. Simultaneously one of the pupils does the same home work task on the blackboard. Such a form of checking is advisable in case the home work does not contain quantitative calculations or working out of formulae and equations. Sometimes, the teacher may thoroughly verify and evaluate the home work of the different pupils, e.g., at the start of a lesson in mathematics he may give a test paper for seven to ten minutes, containing questions similar to those given for homework.

While verifying pupils' note-books, a teacher should pay the utmost attention to the correctness of calculations and to whether the pupils have done the work systematically.

The teacher should also write on pupils' note-books remarks, recommendations, additional exercises to be done, etc. Special attention should be given to language and expression, which should be simple, clear, precise and scientifically correct.

(C and D) Checking with the Help of Experiments Done by the Pupils. The essence of this checking is to give to one pupil or the whole class an experimental task during the course of which the teacher observes, asks questions, looks through their calculations, etc. We have already discussed in this paper methods of checking pupils' knowledge and skills with the help of experiments in the process of oral checking.

Checking pupils' practical skills while they carry out laboratory experiments presents a great difficulty for the teacher since he cannot fix his eyes on the whole class. But the teacher may concentrate on observing in detail four to six pupils, and at the same time, watch the whole class working.

The teacher should evaluate the laboratory work of the pupils whose work he intently observes. Thus, he may evaluate the laboratory work of four to six pupils in a period.

The control practical work is an extremely fruitful method of checking pupils' knowledge and skills. At such a control lesson pupils are given experimental problems, requiring the exercise of the entire scope of their knowledge and skills obtained in the course of studying one or two themes.

For independent solution of the experimental problems, pupils should map out the plan of solving the problem, sketch the needed apparatus, demonstrate an experiment and write an account, etc.

The following are some examples of experimental problems for practical work in Class IX on the theme 'Halogens'.

Problem 1. Prove experimentally that hydrochloric acid consists of hydrogen and chlorine.

Problem 2. Prove experimentally that

the substance given to you is sodium bromide.

Problem 3. Carry out reactions characteristic of: (a) hydrochloric acid, (b) sodium chloride.

Problem 4. Detect among the packets of solids given to you: sodium chloride, sodium bromide, sodium iodide and sodium carbonate.

Problem 5. Add zinc dust to a test-tube, half full of bromine water, Stir it with a glass rod and heat it lightly. Do not stir it for a while. In case a colourless liquid is obtained, pour it into two test-tubes. In case the liquid does not become colourless and the zinc has been completely used up, add some more zinc, stir the mixture and heat.

Add chlorine water to one of the test-tubes and silver nitrate solution to the other. Observe and explain the changes that occur.

Problem 6. Detect which of the test-tubes given to you contains: (i) hydrochloric acid, (ii) sodium hydroxide.

By giving pupils control experimental work, a teacher is able to check their theoretical knowledge and their ability to apply their knowledge to solve practical problems.

The main requirements for carrying out laboratory work are:

(a) Complete preparation of experiments, including a precise assembling of apparatus;

(b) The correct order of carrying out of operations in the process of an experiment,

(c) The ability to explain and deduce correctly;

(d) Observing the rules about handling reagents and equipment;

(e) Cleaning the place of work;

(f) Writing up an account reflecting a pupil's work, observations, deductions, etc.

In mathematics it is necessary to check the skills and habits of using instruments like the slide rule, dividers, calipers, set square, etc.

A teacher should fix in advance the dates and themes of written control work and practical work and a summary of the talk. Besides, a teacher should coordinate the dates for carrying out these items of work, lest they should clash with other work.

Summing up, one can say that a system of checking pupils' knowledge and skills requires a variety of methods, since each method has its particular purpose and facilitates the most effective examination of the different aspects of the knowledge and general development of the pupils.

Gradation of Pupils' Achievements

Evaluation of pupils' knowledge stimulates them to develop better attitudes to sudy Quesions on a lesson should be followed by the teacher's evaluation of the pupils' knowledge and abilities. This evaluation should characterize briefly the form of the scale used to mark the level of knowledge attained by the pupil. While the evaluation of knowledge and abilities stimulates pupils' diligence, the announcement made by the teacher in the class about the mark given to a pupil, along with the full reasons for it, is even more stimulating.

The main requirement of a mark is its objectivity. It should reflect the real level of a pupil's knowledge and must be *neither* an *overestimate nor* an underestimate.

The following could be a convenient five-point scale:

Excellent (Mark 5) is the highest mark, evaluating not only knowledge of the content, but also the form of its delivery. That is to say, the answers should be correct scientifically; they should be complete, revealing a concrete idea of the subject, and comprehension of the problem; they should indicate ability to apply theoretical knowledge to practice; and they should be consistent and properly worded.

Good (Mark 4) is a mark evaluating knowledge that satisfies the above-mentioned requirements. But the answers may contain a few inaccuracies, which can easily be corrected by pupils themselves, and also small defects in delivery. The answers may be incomplete.

Fair (Mark 3 is a mark evaluating an answer correct generally but unschematic, or an answer which may not be concrete but vague. While answering, the pupil encounters difficulties in the analysis and generalization of the factual material. The mistakes are corrected by the teacher with or without the help of other pupils

Poor (Mark 2 is a mark given in cases where the pupil does not know the basic material and makes gross mistakes.

Very Poor (Mark 1) is given when the pupil has no knowledge at all and does not understand the material studied. 'Very poor' is given in extraordinary cases where the pupil does not systematically prepare for the lessons.

The level of the pupils' knowledge required increases in the higher classes. Pupils of senior classes should analyse more deeply the material under study. They should be able to come to independent conclusions, based on observations and experiments, to phrase in precise terms the regularities of living nature, to express the material completely and accurately, and to cite additional popular and scientific literature.

Maintaining the Register of Records

When the teacher knows the methods for constant checking of pupils' knowledge and the method of grading, he should keep a complete record of the achievement marks obtained by each student.

The marks obtained by three to six students in a period should be announced in the class and then entered in the record register. This register will not only tell the day-to-day improvement made by the students but will also reflect the effect of the teaching. The topic or the lesson taught by the teacher and the home work given will also be entered in the same register. If possible, the teacher may also record under his signature the marks obtained by the individual students in their dairies.

Submarine Geophysics

MORE than 20 years before experts proudly announced that, with the aid of artificial satellites, they had established the true shape of the world, the details were known. As far back as the nineteen-thirties the Dutch professor Felix Andries Vening Meinesz (born on 30 July 1887) had established it. When the results of the American satellite reconnaisances were made known, he smiled and said: "They have not made any mistakes; but it is not so simple as all that!"

By courtesy: Royal Netherlands Embassy, New Delhi

Prof. Vening Meinesz

He was too modest to engage in further comment. I recall a conversation with Prof. Vening Meinesz in which he told me:

> They made a good deal of fuss about my work at the time. It was only because of the spectacular external aspects. The public has hardly ever shown any interest in the scientific side, and rightly so to a point, because work of equal or higher quality in other scientific fields is going on in the laboratories of every university in the Netherlands and there's little interest in that either.

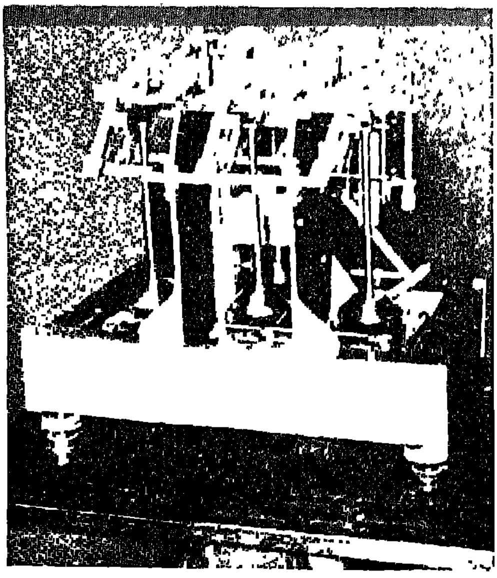
Several decades ago, however, the Professor did attract public attention on a large scale. That was when he made a number of journeys by submarine. The submarines in which he travelled were provided by the Dutch and — on two occasions — American navies. It all started with a strange and unexpected commission which could not be fulfilled until a certain discovery had been made.

Professor Vening Meinesz had qualified as a civil engineer but he had rather an aptitude for pure scientific research, and he eagerly grasped an

opportunity to carry out several projects in this field.

That was round about 1910. At that time the international geodetic commission drew up plans to carry out gravity measurements all over the world. Three points were chosen for measurement in the Netherlands. The Dutch may pride themselves on having won their country, yard for yard, from the clutches of the sea; but the fact remains that the soil is unsatisfactory in some respects. It was too soft for the delicate measurements which Vening Meinesz wished to make, and vibration and movement eliminated the possibility of a satisfactory result.

This led the young engineer to embark on the development of a new instrument, the three-pendulum gravimeter, which is now used for gravity measurements almost everywhere in the world and which is virtually insensitive even to a ship's movements.



The three-pendulum gravimeter

From the very beginning young Vening Meinesz knew that a plan existed for world-wide gravity measurements which ignored the oceans. These accounted for more than two-thirds of the earth's surface, but there just was not an instrument in existence capable of undertaking gravity measurements while being operated on a pitching, rolling ship.

The instrument which Vening Meinesz developed and which earned him a degree was workable on a ship undergoing moderate movements. Unless the instrument could be improved upon, the problem was to render the restrictions on its operation ineffective. So what about an underwater craft? A submarine fathoms below the surface would fulfil the required conditions even in rough seas.

There followed a period of fifteen years (1923-1938) in which Vening Meinesz undertook ten voyages, travelling, for instance, from the Netherlands *via* the Suez Canal to the former Dutch East Indies, across the Atlantic Ocean *via* the West Indies, the Panama Canal and the Pacific, and again *via* the South American continent, the Cape of Good Hope and West Australia, to the same destination. It was these voyages more than the work which was carried out on them that brought fame to him. That work consisted of submerging and submerging again, all the time taking gravity measurements. These provided an important basis on which the young civil engineer could further theorize.

Below its rigid, 35-kilometre thick crust, the mantle of the earth reaches down to a depth of 2900 kilometres. Vening Meinesz found that in this mantle vast current systems occur,

proceeding at a speed of a few centimetres per year. The currents cause strong deformations of the crust. Where it is compressed, folded mountain ranges originate. If the crust is under tension, a 'graben' is formed between two rising blocks, e.g., the Upper Rhine Graben between the Vosages and the Black Forest. Where one crustal block is moving along a so-called fault plane (a rift) in regard to another block, these movements give rise to severe earthquakes such as the San Francisco earthquake of 1906.

One of these current systems rises under the Asian continent, travelling roughly south-east. This causes strong crustal deformation in the Indonesian Archipelago; hence the earthquakes and volcanoes in this area Similar phenomena occur in the Philippines and Japan. The deep 'trenches' in the Western Pacific are likewise symptoms of the crustal compression caused by this current system In addition to the geophysical conclusions already mentioned, the gravity material obtained on Vening Meinesz' submarine cruises was also important in determining the 'figure' (shape) of the earth. It was known at the time that the earth resembles an irregular potato and not, as was argued (in view of satellite findings), a pear. But very likely it will not prove to be as irregular as was supposed. The deviations (and this applies to oceanic deviations as well) probably never exceed 40 metres

Satellite observations are admittedly of great value for the establishment of the figure of the earth. In this field, there is still a great deal of work to be done. However, details of the deviation of the earth's surface, such as revealed by Professor Vening Meinesz and others, will never be obtainable by satellite observation As the Professor put it: "It's not so simple as all that!"

Low Temperatures

OF the many branches of physics, low-temperature physics has a place all to itself. This is the world of phenomena that appear in the neighbourhood of absolute zero. While the scale of temperatures is apparently unlimited at the top (we could heat a substance indefinitely if we had the means), we reach an inviolable threshold when we lower temperatures. This threshold—around 273 degrees below zero degree Centigrade—is called absolute zero. And man will never achieve absolute zero, because each fractional drop becomes more difficult to achieve, the closer one draws to it.

We have chosen low temperatures as a crossroads because they, and their quite special techniques, are now at the heart of a number of discoveries in widely different fields. By tracing their role in each field, we can see their importance in research on the constitution of matter (here, the study of liquid helium has resulted in a great deal of data). We shall also be able to understand the many uses of superconductors in technology, whether as powerful multipurpose magnets, as parts of electronic brains, or as aids to the construction of tomorrow's electronic devices.

Low-temperature physics entered our universe at the beginning of this century when a Dutch physicist, Kammerlingh Onnes of Leyden, stubbornly set out to achieve a temperature as close as possible to absolute zero. With the facilities then at his disposal, he spent most of his efforts in trying to bring objects down to temperatures at which the very air we breathe becomes rock-hard. Onnes pursued his *idee fixe* till he opened the door of a world so remote and so inaccessible that he would have been quite startled to see his experiments become everyday practice in industry. He was awarded the Nobel Prize for this research.

First of all, Onnes succeeded in liquefying helium, one of the family of 'noble' gases, so called because they are chemically inert and refuse to combine with other elements. Helium, a very light gas and the second element after hydrogen on the periodic table, is

From Science Today

particularly hard to liquefy through cold. This most rebellious of gases becomes liquid only when it is chilled to 269 degrees below zero Centigrade As yet no one has succeeded in freezing it into a solid state When it becomes liquid, it takes on some unique properties which are now revealing to us certain secrets of matter. To Onnes, it was mainly a convenient way of cooling other substances, just as you cool a bottle by placing it in iced water. His method is still used today—on a larger scale

Liquid helium does not merely provide a convenient way of cooling objects under study; it is itself one of the strangest liquids in existence, and a fascinating subject of research. According to its temperature (that is, within the narrow range from −269° to −273° where it remains liquid) it may behave like any ordinary liquid—it can be shaken, or stored in a container—or else it may suddenly acquire unexpected properties For example, it can lose all viscosity and become 'super-fluid'. Then it easily passes through holes so small as to be non-existent. Or it can climb the walls of its container and escape over the brim. These are manifestations of the phenomena governing the behaviour of the elementary particles that compose matter. The study and understanding of these apparently inexplicable facts can therefore tell us about the intimate properties of matter and energy, and of how they interact. Lev Landau, the Soviet scientist, received the Nobel Prize last year for having shed fresh light upon these phenomena.

Onnes overlooked liquid helium's strange behaviour, but he did discover a number of new phenomena by plunging different substances into his cold bath. The most unexpected and the most rewarding was the superconductivity of metals, a rare example of perfection in nature. By chilling metals to the vicinity of absolute zero, it has been observed that some of them become 'superconductors' at a given temperature—that is, they conduct electric current without offering the slightest resistance.

This resistance, a form of friction created when current is passed through any normal conductor, disappears as if by magic once a certain temperature threshold has been crossed. This threshold, more than twenty degrees above absolute zero, varies from one metal to another. If an electric circuit is created with a specific metal (about thirty such metals are now known, and new ones are being discovered all the time), and if this circuit is sufficiently chilled, and an electrical impulse sent over, it will continue to flow for years without weakening and without requiring a generator to maintain its strength, as in the case of ordinary circuits.

This peculiar property of certain metals and alloys obviously had some attractive applications. It was a tempting idea to use superconductors to achieve electrical connections without any losses so that extremely strong currents could be carried by very small cables, for this would have cut down heavily on the use of costly metals. But, first of all, how could you keep an electric power line crossing the countryside at the temperature of liquid

helium? This was certainly beyond the reach of technology, and, of course still is

Then an even more serious obstacle sprang up: as soon as a superconductor is placed in a magnetic field of sufficient strength, its 'perfect' state ends and it acts like an ordinary conductor, even if its temperature is still low enough to enable it to remain a superconductor without this magnetic field. Naturally, when you send a current through a wire, this current creates a magnetic field which increases with the strength of the current. In other words, as soon as anyone tried to harness superconductivity, it automatically disappeared. It looked like a blind alley.

To overcome this major problem, physicists, chemists and technicians joined forces. This research began many years ago, and is in fact still going on. But the first positive results are already encouraging: superconductors whose properties remain unchanged even by strong magnetic fields have been discovered. By sifting through a vast range of alloys, scientists have found some, like the alloy of tin and niobium (a rare metal, somewhat like bismuth), that maintain their perfect conductivity while allowing extremely strong currents to pass. Although researchers are still trying to discover an alloy that has the best characteristics, engineers are already using an arsenal of new metals.

At the same time, low-temperature techniques have made such enormous progress that it is now almost routine to chill even large masses to the vicinity of absolute zero. Liquid helium, which is being used as a cold bath for these objects just as in Onnes' time, is now mass produced and laboratories can buy it as an ordinary commercial product.

While it is not certain that the high-tension lines now criss-crossing industrial countries can be rapidly replaced by networks of superconductors (although some serious thinking is being done on the subject), these materials have already been used to build transformers in which miles of wire are compressed into a small space. In the future, big transformers using superconductors will be much less bulky than our present-day monsters, and incomparably more efficient.

Magnets for Moulding Metals

In the same manner, it is now possible to construct electromagnets more powerful than any in existence. The ordinary electromagnet, a huge coil through which powerful currents are sent, reaches its peak at a few score thousand gauss (The gauss is a unit measuring the strength of a magnetic field, an ordinary horseshoe magnet, for example, produces a few hundred gauss.) These electromagnets consume huge amounts of electric current that just heats them up—and then whole torrents of water are needed to get rid of all this heat.

Electromagnets with superconductors are making their appearance, and will soon be able to create magnetic fields as high as a million gauss, consuming virtually no power at all. These magnets will be powerful enough to shape steel as if it were clay, and it is quite possible that the enormous presses of today, the pride of our steelmen, will eventually give way to coils wound

with superconductors. When properly placed, these coils will produce magnetic fields whose direction and intensity can be controlled, and which will mould steel ingots into whatever shape is needed.

A product of progress, superconductor magnets will contribute to progress in their turn. It will be possible to gain a better understanding of the structure of matter and the forces that give it cohesion by using these unprecedented magnetic fields. This is a feedback process: yet again we find research leading to achievements which, as soon as they are perfected, contribute in turn to its progress in fields very remote from the ones that developed them.

Technology will also benefit from superconductor magnets. Tomorrow, for example, our electric power will be produced directly from heat, without going through the long process that makes up the ordinary steam-power station: furnaces, boilers, turbines, alternators, and so on. This process extracts in useful form only a fraction of the energy contained in the original fuel, most of which is consumed by all these 'middlemen'. But soon devices for directly converting heat into electricity will break all efficiency records.

Among these short cuts in electricity production, the most promising seems to be the magnetohydrodynamic generator. This is the mysterious name for a simple tube placed in a powerful magnetic field. A high-speed jet of very hot gas, produced directly by burning whatever fuel is used, is shot into the tube. This gas is ionized because of its temperature and because of a preliminary treatment which it undergoes. As a result, it becomes a conductor which allows electric current to pass, unlike cold gases, which act as insulators. The movement of this gaseous stream through a magnetic field generates a current which has merely to be tapped. There is a long way to go before this process reaches perfection, and a number of problems still have to be solved. But specialists have every chance of success, and they will find superconductor magnets indispensable for producing the field required by the generator.

These same magnets will also be of tremendous help in the construction of large particle accelerators (which may well be larger than a sports stadium) that now enable us to penetrate the intimate recesses of matter. In these devices elementary particles are accelerated by intense magnetic fields that send them spinning on a sort of gigantic, very precise merry-go-round. Superconductors will perhaps be used to produce these fields

The study of elementary particles also makes use of very low temperatures in another way. One of the indispensable accessories of a big accelerator is the 'bubble chamber'. In this the trajectories of invisible particles take shape as necklaces of tiny bubbles within a special liquid whose atoms also serve as targets for these particles once the accelerator has given them enough speed. Each collision of a particle with atomic nucleus in the liquid gives birth to showers of new particles which appear against the chamber's black background, and are photographed before they vanish.

By examining hundreds of these photos, scientists have discovered a

host of new phenomena and certain particles that had previously gone unnoticed. It was in this way, for example, that researchers at Brookhaven, in the United States, and at CERN in Geneva (the European Organization for Nuclear Research), discovered simultaneously, with similar apparatus, a new elementary particle, the anti-ksi.

In both cases, studies had to be made of tens of thousands of photos taken in bubble chambers. These chambers are within the scope of low-temperature research because they are usually filled with liquid hydrogen, a gas extremely difficult to liquefy. Present bubble chambers are more than three feet in diameter, and it is quite a feat to produce apparatus of this sort where temperatures must remain perfectly stable at a level of about twenty degrees above absolute zero. The bubble chamber would not exist without the long tradition of research in low temperatures.

Two Extremes of the Temperature Scale

This concourse of nuclear physics and low-temperature techniques offers us yet another hope. Superconductor magnets may be used to achieve the 'magnetic bottles' required for taming fusion energy. Ever since the development of the H-bomb, scientists have been trying to control this form of energy, just as fission energy is controlled in nuclear reactors. The solution is still a long way off.

The problem is to place in an appropriate container a 'fuel' consisting of a mixture of heavy hydrogen isotopes, then to bring this mixture to temperatures like those in the centre of stars (some tens of millions of degrees) for a long enough time. Under such a temperature, the nuclei of the hydrogen atoms would combine to produce heavier atoms. At the same time a considerable amount of energy would be released and this would keep the reaction going.

Two major obstacles thwart this project. In the first place, the stellar temperatures needed to start the reaction have yet to be achieved. In the second place, a container that will stand up to such a temperature must be found.

Work on the first problem is slowly progressing. Under the onslaught of physics and technology, the temperatures obtainable are rising continually, and so is the length of time they can be maintained. (Obviously, it is not possible to set off this reaction in the laboratory by exploding an H-bomb!)

The second problem still seems insoluble: gas brought to such temperatures cannot be contained in any known recipient. If it merely grazed the wall of a container, the container would disappear, and the gas itself would lose its high temperature.

This plasma (plasma is a state of matter different from the three generally recognized states—gas, liquid and solid, in this state of ionized matter atoms have lost the electrons that usually rotate around their nuclei) can be contained only in a very powerful magnetic field of a certain shape, a sort of invisible 'bottle,' which is still evading scientists.

Theoretically, such a field could keep hot gas away from the sides of a tube. Extremely powerful magnetic fields are needed to hold back particles launched at the sides of this tube at high speed.

It is not inconceivable that magnets constructed with the help of superconductors can be of considerable use to research workers in this field.

There is still another important field of application for superconductors, and one which may be decisive for the advancement of science in the future: the field of the electronic brain. The fact that, in most superconductors, a magnetic field can destroy the superconductivity of a wire placed within the field —and that this superconductivity reappears as soon as the field vanishes— has given specialists the idea of new circuits for electronic computing.

This means that low temperatures could be used to solve one of the crucial problems of our time Giant computers are among the most prized tools of modern research. Every few months, their total number in the world doubles; they are being developed so rapidly that manufacturers are afraid to go into mass production in case their machines become obsolete before they can be used. The requirements of the scientific consumer are going up steadily, as is the complexity of the problems to be solved. To meet them, it is becoming necessary to build computers one hundred or one thousand times more powerful than the ones now in use.

A setback in the field of the electronic brain would compromise the advance of science in far too many realms. This is why various branches are now making a common effort. Solid-state physics, the science of semiconductors, the chemistry of high-purity compounds, mathematics, molecular electronics and bionics are all working together to perfect the technique of giant programmers Above all, the capacity of their 'memories' and their speed must be increased.

The letter problem depends very *much on the dimensions* of these devices. In effect, computations are made with the help of electric impulses travelling at the speed of light. This speed may seem infinitely high to us, but it is already beginning to set limits on the rate at which computations can be made. We now ask electronic brains to perform a thousand million operations per second. Each one, therefore, must last less than one thousand-million of a second—an interval in which an electric impulse travels less than one foot. If the size of the computer is increased, then impulses waste time travelling instead of doing useful work. In other words, in order to make more powerful computers, their size must be drastically reduced.

Superconductivity offers some original solutions to this problem. Cryotrons—small components that replace ordinary memory and switching devices—are constantly shrinking, enabling a large number of circuits to be housed on small surfaces. The principle on which they operate is a simple one: two wires of different metals, both superconductors, are placed side by side. If a current, even a weak one, is sent through one of these wires, it creates a magnetic field around it. The second wire is designed in such a way that its neighbour's magnetic field should be enough to eliminate its own superconductivity A current, even a weak one, going through the first wire will therefore block the movement of a strong current through the second wire. On the other hand,

as soon as the first current is cut, the second can move without any difficulty. This is a basic operation for the electronic computer.

The main disadvantage of the cryotron computer—the need to chill it in liquid helium can be greatly overcome by designing smaller units. On the contrary, one of their advantages is that they require only a very small amount of power to operate because of the incomparable efficiency of their superconductors.

Today it is not at all certain that cryotronic brains will replace the ordinary computer working at ordinary temperature. However, they look promising, and in some special cases, such as in space vehicles, may offer considerable advantages.

The Electroretinogram

A New Avenue of Research into the Brain

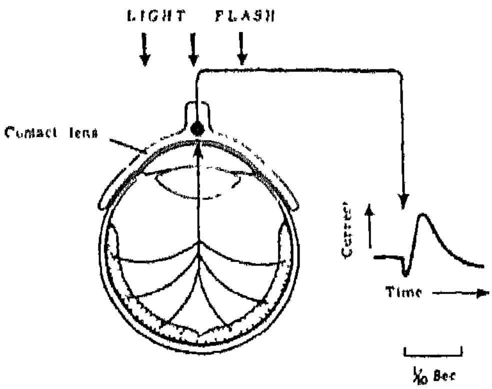
A fresh way of exploring the workings of the brain has been found by London medical research workers. They have made a device called an electroretinogram. Broadly speaking, it performs the same function for the eye as the electrocardiogram performs for the heart or the electroencephalogram for the brain. Both these are now used normally in treatment of patients and it is hoped that the electroretinogram will likewise become used by ophthalmologists all over the world.

In principle, the electroretinogram records the tiny electric currents or impulses that occur in the cells of the eye when they are stimulated by light or some other cause. These currents can be picked up by small electrodes which are attached to the patient, implanted in him or stuck on to a special version of the 'contact lens' (a piece of glass or transparent plastic to overcome seeing defects which fits over the eye-ball and under the eyelids, and which is in contact with the eye itself).

The original purpose of the machine was to enable the doctor to tell whether

Reproduced with kind permission from **Spectrum**, 29.2-3, October 1966

Dr G B Arden of the Institute of Ophthalmology in London inserts a contact-lens electrode to record the activity of the nerve cells of the retina.

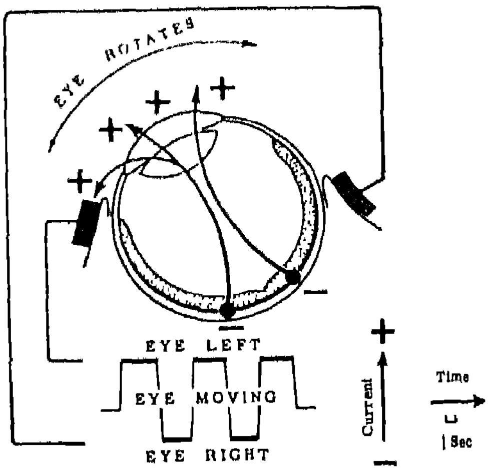


The retina (stippled) only produces current when a light flash enters the eye. It responds so fast that the current is measured directly.

the retina, that is, the layer of cells at the back of the eye which is responsible for sending signals to the brain when light falls on it, was still working properly when it was possible to look at it. The easiest way to picture this requirement is to consider the case of a person blinded by cataract, the disease which makes the whole transparent front surface of the eye opaque. Nowadays, it is possible to cure this condition by cutting away the opaque lens and grafting in a transparent lens from the healthy eye of someone who has died and left his eyes for this purpose. There is, of course, no point in performing this operation if the retina at the back of the eye is not working. Usually the surgeon or ophthalmologist can tell if it is working by looking into the eye and performing tests through the transparent front, which he cannot do through an eye affected by cataract.

The electroretinogram was the first machine ever made by medical science which could examine the eye without someone actually looking at it, and it is highly successful as a diagnostic tool. It was devised by a team under Dr. Geoffrey Arden at the Institute of Ophthalmology in London. This Institute is part of the same organization as the world-famous Moorfields Eye Hospital and virtually all the advanced post-graduate training of eye specialists and the corresponding original research into eye diseases for the whole of Britain is done there. After the machine was made in the laboratories of the Institute, it was put to work in the clinics of the Moorfields Eye Hospital.

But its latest development makes it one of the most exciting tools of advanced research on the brain. For just as it can pick up the minute elec-

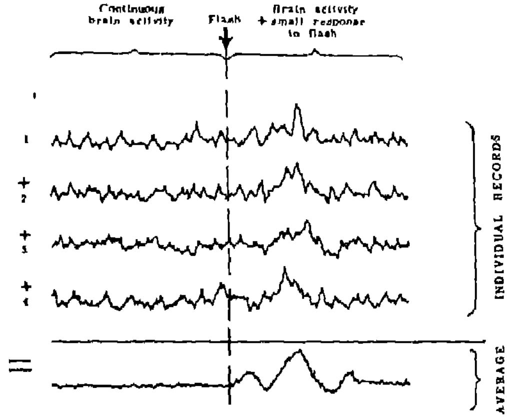


This diagram shows how the electric current produced by the 'feeding cells' is measured. The heavy black line shows the position of the 'feeding cells' in this diagram of an eye. They produce current (heavy arrows) so that the eye is like a battery. The current is picked up by wires on the skin near the eye. As the eye rotates, the current alters as shown below. The size of the eye-movement current depends on the 'feeding cells'. The dimple on it is the fovea.

tric impulses in the eye, so by the addition of extra electrodes on the scalp of the patient the corresponding electrical impulses in the brain can be recorded. It is becoming possible to track accurately the places in the brain where the incoming vision signals are processed. Similarly, there has developed greater sensitivity and accuracy in detecting exactly where in the eye the incoming light is turned by photochemistry into electrical nerve signals.

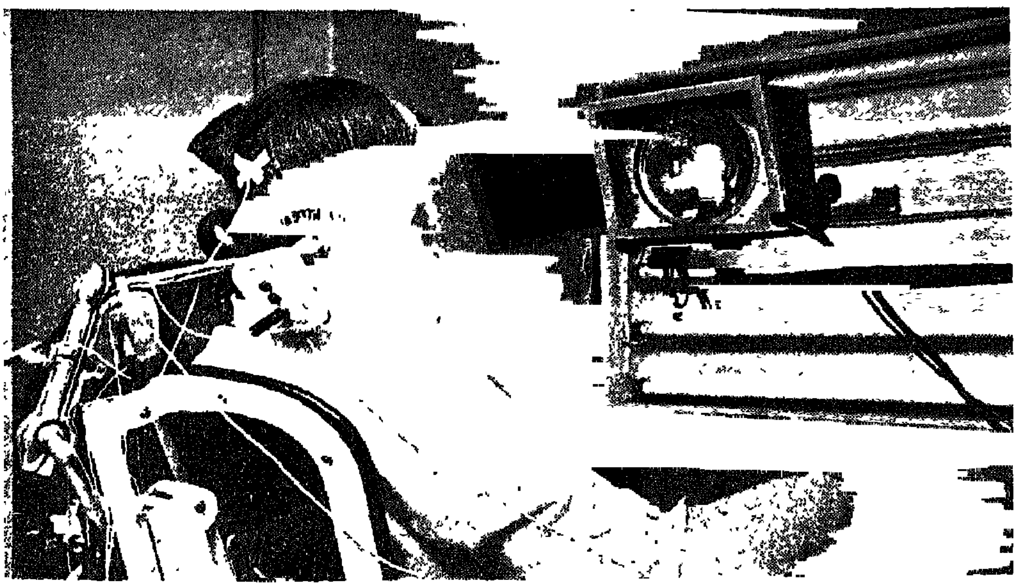
To the scientists in the team the eyes are part of the brain and not only because of direct physical contact. The questions that are now being worked out are those of how much processing of the visual signals is being done at each level. What information does the eye send to the brain and how much sorting out and rejection has the eye done before it passes the signals on? How are patterns recognized?

These medical scientists admit that their work borders on that being done by psychologists. They are confident that they are on the verge of completing a map of the processes of vision. But they are careful to point out that this will not explain human perception.



This diagram shows how a computer sorts out the response of the brain in a light flash. In practice, over 100 responses are averaged The average voltage shows the response of the fovea

Recording brain activity with an electrode placed on the back of the head. The patient faces the flashing light and the responses are conducted by the wires to a computer.



The Geology of the Moon

GILBERT FIELDER

THE first remarkable close-up views of a sample of the lunar surface were recorded by the camera of Luna-9 and transmitted back to earth early in February 1966. Details smaller than one centimetre in size are apparent on the Soviet photographs whereas, in the more comprehensive Ranger series of photographs taken earlier by the United States, the smallest objects visible were 10 to 100 times bigger. Because the aims of these particular American and Russian programmes differed, the data drawn from each set of results are supplementary and, together, benefit lunar research greatly. Yet it must not be imagined that the results from recent space probes have eclipsed the decades of laborious lunar research performed from earth-based observatories. This accumulated stockpile of lunar material is invaluable in any discussion of lunar geology.

One of the striking properties of the moon is the disparity between the brightness of different parts of the surface. The more highly reflective parts are referred to as 'lunarite' and the darker parts as 'lunabase'. Large areas of lunarite are called 'continents' and specific areas of lunabase, 'maria'. Several of the maria are roughly circular and the largest—Mare Imbrium—measures some 1300 km from edge to edge. The surfaces of maria undulate on a scale of tens of kilometres but carry few mountains: from our vantage point on the earth they are characterized by an apparent—and deceptive—smoothness. By contrast, the continents are mountainous and the mountains and lesser eminences generally form parts of the 'ringwalls' of maria and 'craters'.

Most authorities agree that lunarite is probably acidic rock whereas lunabase is relatively basic in composition. Certainly, it is generally agreed that the maria are lava-flooded regions and that the lava came later than most of the luna craters—possibly as a result of the heat generated by the decay of radioactive isotopes. Opinions differ as to whether the maria were originally dry

Reprinted from Spectrum, 24. 10-12, May 1966

craters shaped by titanic collisions, the craters later becoming flooded, or whether they are purely tectonic features, in other words, caused by movements of the moon's material. Similarly, the continents have been built up predominantly, it is argued, either by the impacts of meteors or igneous and volcanic activity.

There are many different types of crater on the moon For example, some are rudely circular whereas others depart from the circular shape—they might be rectangular or hexagonal, like ptolemaeus. Each linear-type segment of the wall of a polygonal crater is generally aligned in a direction that is paralleled by the strikes of regional faults or fractures, and this suggests that such walls are fracture-controlled.

The ringwalls of large craters slope outwards at a few degrees and inwards at mean angles that rarely make more than 30° with the horizontal. There are many benches in the walls of large craters such as the 98 km diameter Arzachel, and the slopes of specific *parts of ringwalls can differ* considerably. The majority of the smallest craters photographed by Rangers 7, 8 and 9 and Luna 9, have inner slopes of less than 10°. Some of the craters recorded in the Ranger series of photographs are particularly interesting; they have been described as 'dimple craters'. In shape and contour they are similar to the pits produced in some lava fields on earth by liquid lava withdrawing beneath a solidifying crust of cooler lava.

Lunar faults can often be recognized and classified with less difficulty than in the case of terrestrial faults. The Straight Wall is a well-known dip-slip fault in an exposed position in Mare Nubium. Its length is about 120 km, the dip is between 10° and 40°; and the downthrown block has suffered a relative vertical displacement of some 300 metres. Other well-exposed faults with normal components of displacement are found in Mare Humorum, Mare Tranquillitatis (The Cauchy Fault) and in Lacus Mortis. The Altai 'selenofault' probably follows a complex of dip-slip faults There are hosts of other normal faults for which there are no measurements of dip or throw.

Although the Apennine front has a dip-slip component of motion, this is accompanied by a lateral component. Strike-slip faults are probably commoner on the moon than are dip-slip faults Possibly lateral movements of up to 200 km have taken place in the case of the oldest recognizable faults. The more recent strike-slip faults show smaller offsets, but many of these may still be measured in kilometres.

As the most important faults seem to be associated with the zones separating *the maria from the continents, it is* reasonable to suggest that the fault movements represent particular diastrophic phases in a general pattern of stress-relief associated with the growth of maria. (Diastrophicen means a sequence of rapid change in the surface followed by long spells of slow change.) Indipping crater-rings situated around the outside edges of maria suggest a state of isostatic control where equal masses of material underlie equal areas Indeed, the maria are of darker, possibly more basic, rock than the continents and it is possible that a state of isostatic balance exists with reference to the surroundings.

The whole face of the moon carries a complex of lineaments, consisting of elongated horsts or parallel normal faults (frequently, segments of the walls of polygonal craters), graben (in which the strip between the faults has subsided), crater-chains and faults. The writer distinguishes three strongly developed systems of lineaments. System A, trending SW-NE in regions close to the centre of the moon's disc; system B, trending SE-NW; and system RI, a regional system oriented sub-radially with respect to Mare Imbrium.

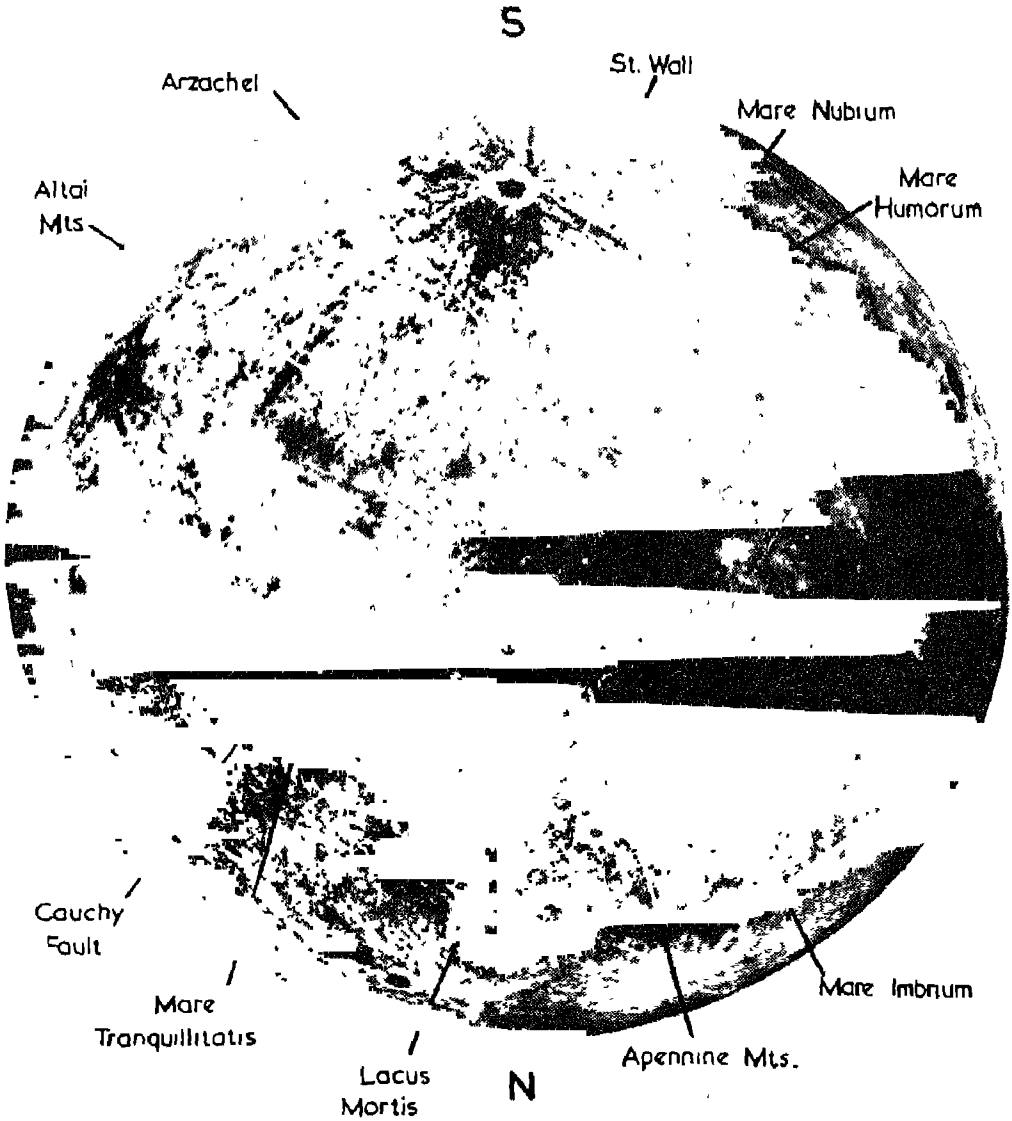
There has been much discussion as to whether system RI was produced by fragments hurled away from the centre of impact with a meteor in Mare Imbrium or whether the system of radiating lineaments arose in fractures. Most authorities support the latter hypothesis but differ on whether the fractures themselves were produced by a collision or, over a protracted period of time, by stresses generated in Mare Imbrium through a process of subsidence.

Photograph of the moon's surface taken by the US Ranger moon probe.

It may be shown that many of the lineaments originated in strike-slip faults. Small craters frequent the crests of horst lineaments, which may therefore be formed by volcanic materials extruded from fissures. This argument is strengthened considerably by the fact that the ridge-top craters are commonly elongated in the direction of the axial trend of the ridge, thus, these particular craters cannot be of impact origin.

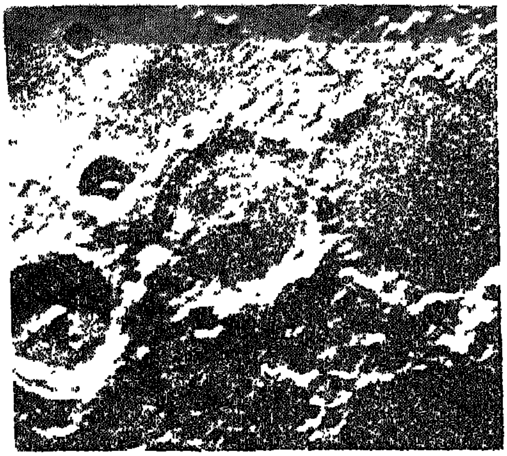
While evidence that some of the lunar craters are of internal, rather than external, origin has been given above, at least some of the craters on the moon must be impact craters. In general, the form of a relatively deep, well-sculptured lunar crater is consistent with its being of explosive origin, and it is known that meteorites striking the moon at all except glancing angles of approach would penetrate only a short distance and compress the rocks in their path to generate a high-pressure high-temperature gas that would then explode to excavate a substantially circular crater.

However, tests for randomness of the distribution of craters of given diameter show that craters smaller than 40 km in diameter are not distributed at random: they form chains or clumps. The chains are associated with tectonic features and the clumpiness of the craters also supports the theory that the majority are not caused by impact. Therefore, craters of both types must be present on the moon.



A view of the moon, showing some of its main features

The spectrum of the reflected light of the moon is similar to the solar spectrum in the visible region and has a characteristic absorption in the ultra-violet. Faint luminescent bands have been detected and compared with the luminescent bands of rock samples that have been subjected to proton bombardment so as to simulate the solar wind—of nuclear particles—that plays, unimpeded by an atmosphere, on the moon's barren surface. Spectrophotometric data have been used together with polarization, thermal and radio-



The large lunar crater Arzachel which is 98 km across

wave data in attempts to determine the chemistry and the physical state of the lunar materials. No unambiguous chemical or mineralogical indentifications have been made, because in practice many laboratory specimens can be found which match the observed properties of the moon. A trace of the element sulphur common in volcanic sublimates would produce the observed ultra-violet absorption.

On the other hand, years before Luna 9 touched down on the moon to confirm the theory, it was known from physical studies that the upper layers of the moon were in an under-dense, porous state. Radio soundings of the

A view of the horizon of the moon as received from Surveyor I. The spacecraft's camera was pointed almost directly at the sun, which is out of view. The bright circles are reflections of sunrays. Surveyor I made a 'soft' landing in the moon's Ocean of Storms. It was launched from Cape Kennedy in Florida.

top metre of the lunar soil had pointed to materials with very low bulk densities. Many people, including the writer, found reasons for identifying these material properties with those of on the surface and fragment the rocks However, that the process is a slow one is proved by the present rate of meteoritic erosion on the moon, based on rocket counts of the space-density

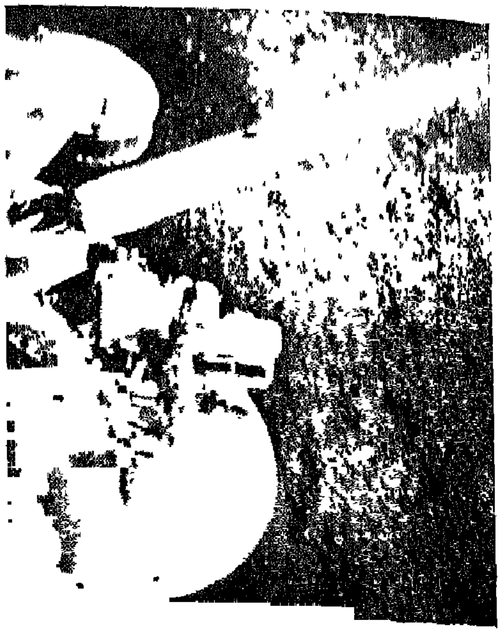
The relatively small depression made on the surface of the moon by Surveyor I as it landed is visible as the dark area above the landing pad in this 600-line picture. The bright spots at left are reflections of the sun, and the dark rings at lower right are reflections of the camera in the mirror through which the photographs were made.

lunar lavas for, in the virtual vacuum above the moon's surface, materials erupted there would outgas and expand to form a rock-froth that, clearly, would be more porous than in the corresponding terrestrial case.

Also, because the moon has no atmosphere, meteorites slam unhindered of particles close to the planet. In any case, the 'dust' particles produced in this way are subject to the sputtering effect of solar protons and in the vacuum conditions above the moon's surface, must stick together to form a crystal structure having a small but finite strength.

In the near future, lunar probes equipped for chemical and geological analysis will follow Luna-9 and set down lightly on the lunar soil, and the success of these experiments will open a new era in lunar exploration.

A small lunar crater, a rock six inches high and 12 inches long (15 by 30 centimetres) and smaller pebbles on the moon's surface show in this 600-line picture received from Surveyor I. The lunar horizon is seen at upper left. The Surveyor camera was pointing south-east on the moon for this picture. The bright spots at left are reflections of the sun. Lines represent interference in the transmission and receiving process.



This is the first 600-line photo received from Surveyor after its historic 'soft' landing on the moon. The picture shows one of the craft's three landing legs above, an omni-directional antenna boom at centre, and a helium container at the bottom. The disturbance of the lunar surface by the landing pad is also visible. The camera system aboard Surveyor provides both 200 and 600-line pictures. The latter require use of the high-gain directional antenna and a high power level of transmission. The 600-line mode provided a picture every 3.6 seconds of transmission, and the 200-line made a picture every 61.8 seconds.

Around the Research Laboratories

The National Metallurgical Laboratory, Jamshedpur

Plans and blueprints for the establishment of the National Metallurgical Laboratory were drawn up soon after World War II for consideration by the Board of Scientific and Industrial Research. The foundation-stone of the National Metallurgical Laboratory was laid at the end of 1946, whilst the nucleus of the Main Building and the Technological Block of the National Metallurgical Laboratory were opened on 26 November 1950. The National Metallurgical Laboratory was established with the objectives of fostering applied and fundamental metallurgical research in India on an organized basis and to serve as a central station for carrying out research and development work on indigenous ores, minerals, refractories, ferrous and non-ferrous metals and alloys, etc., in relation to their potential applications in Indian mineral and metal industries, which were poised for dynamic growth and expansion under the successive Five Year Plans.

A view of the main building of the National Metallurgical Laboratory, Jamshedpur.

Scope and Function

The National Metallurgical Laboratory has since its opening been gradually equipped on modern lines to undertake planned research work on applied projects and fundamental metallurgical subjects, followed by integrated pilot-plant scale trials on potential practical themes culminating in the issue of Project Reports for implementation on an industrial scale of the National Metallurgical Laboratory's researches and processes. The scope of research and Pilot Plant investigations at the National Metallurgical Laboratory is as vast as it has been challenging. This challenge is being effectively met through systematic and painstaking research and development work on diverse themes, comprehensive both in depth and in their scope, at the National Metallurgical Laboratory, which has today attained recognition both overseas and at home as "having a deservedly high reputation in the metallurgical world".

As Indian metallurgical industries are becoming progressively more and more conscious of the utilitarian value of research, a heavy load of technical operational research projects is being systematically handled by this Laboratory to raise economic productivity consistent with quality output. Effective technical liaison is maintained with industry through the various publications of the Laboratory including research monographs and the *NML Technical Journal*.

During the last few years, the National Metallurgical Laboratory has heavily expanded, both in terms of short-term and long-range research schemes and integrated pilot plant research projects, conducted in the following main divisions of the Laboratory under the active guidance of Dr. B. R. Nijhawan Director.

1. Ore-dressing and Mineral Beneficiation
2. Extraction Metallurgy
3. Low Shaft Furnace Project
4. General Metallurgy
5. Chemical
6. Refractories
7. Mechanical Metallurgy
8. Physical Metallurgy
9. Iron and Steel
10. Liaison and Operational Research
11. Alloy Steel
12. Engineering Design
13. Instrumentation
14. Electronics
15. Mechanical, Electrical and Civil Services
16. Library and Documentation
17. Statistics, Economics and Project Reports.

Achievements

The use in industry of an increasing number of metals in diverse forms is largely the result of systematic scientific research designed to meet the new demands of the technologist. In India, this demand has multiplied during our successive Five Year Plans, requiring effective utilization of the indigenous resources of metals and minerals. With the changing pattern of industrialization, covering a wider spectrum, the expanding metallurgical industry has had to face problems in new and challenging fields.

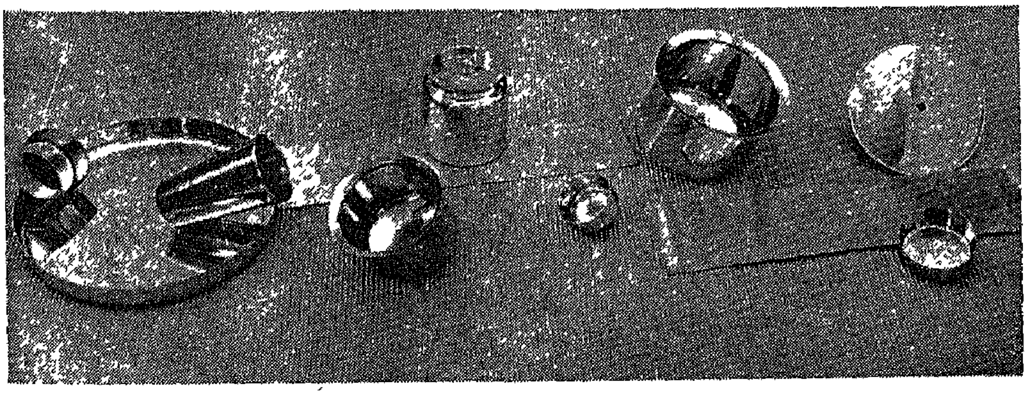
The National Metallurgical Laboratory has wholly dedicated itself to the

growth of indigenous metallurgical and mineral industries against the background of systematic research in basic fields of study. The importance and indispensability of research is now recognized by the country's metallurgical industries, and some of the NML processes and products have received due appreciation both at home and abroad. A brief account of some of the achievements is given below.

Development of Substitute Alloys

No country in the world is self-sufficient in respect of its metal and mineral requirements and India is no exception to this general rule The import of vital metals like nickel involves a heavy amount of foreign exchange, apart from the risk of being cut off from the supply in political exigencies The effect of such shortages has been mitigated by the National Metallurgical Laboratory by developing substitute alloys made by optimum combination of indigenous metals adopting specialized techniques. Take, for instance, nickel, the metal in short supply, which is an essential raw material for producing stainless steel Research and development at the NML have resulted in a new method for making stainless steel without nickel, using chromium, manganese, nitrogen and copper which are available in the country The new steels can replace the famed 18.8 chromium-nickel steel in certain specific applications These nickel-free stainless steel can be used for utensils in Indian households, including tumblers, *thalis, katoris,* spoons pots, pressure cookers, cooking ranges restaurant flat ware, etc For wash-basins and other similar fittings on Indian railway coaches, these steels will prove equally useful. They may also be used for hospital ware, dairy equipment, decorative and architectural parts, steel furniture, high strength structural members, etc, and for applications requiring metals with low magnetic permeability.

Nickel-free alloy compositions have been also developed for replacing the copper-nickel alloy, now used for coinage production in the country Coins stamped out of these new compositions have been found to be satisfactory

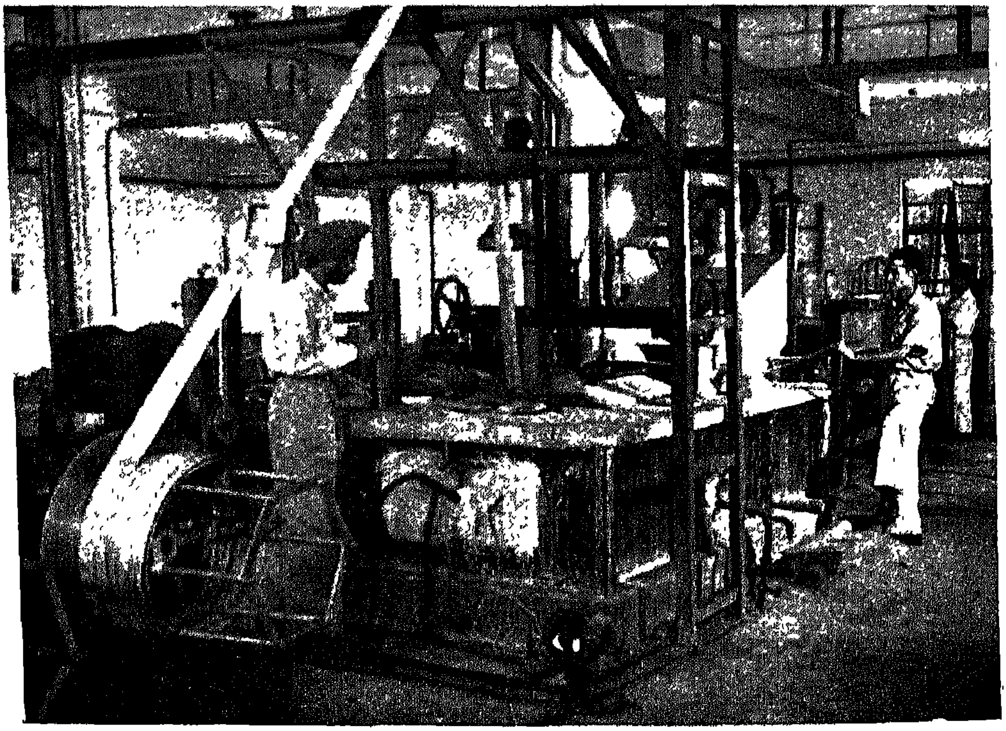


Materials fabricated out of nickel-free austenitic stainless steel developed at the National Metallurgical Laboratory

Another development in this direction is the production of nickel- and cobalt-free electrical resistance alloys which have been found to possess properties similar to the imported conventional types of heating elements used for domestic and industrial heating purposes. To minimize the use of zinc, another metal largely imported, a technique has been developed to give a coating of aluminium on mild steel. the aluminized steel has proved to be better than galvanized material. This process has been studied on a semi-commercial scale; a pilot plant has been fabricated for the production of aluminized sheets and wires. These products can be used in telegraph hardware, automobile parts, corrugated sheets, and for other products which have to withstand corrosion to a large degree. The technique developed has been leased out for production on the commercial scale.

Beneficiation of Low-grade Ores

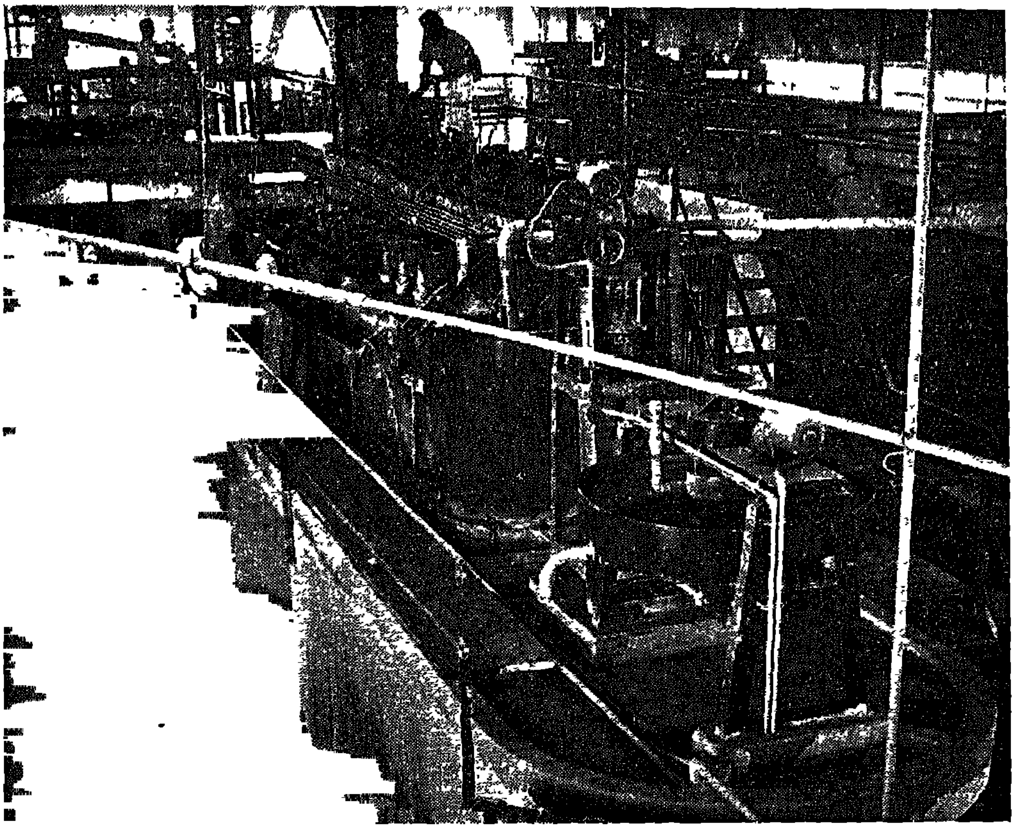
A common sight in the manganese mining localities is the unending series of mountain-sized heaps of rejected ores. These are a legacy of the past when rich ore deposits were mined for export. While the high-grade manganese ore went out of the country, the low-grade ore and fines went into the



Pilot plant for hot-dip aluminizing of steel strips, designed and fabricated at the National Metallurgical Laboratory.

making of these dumps. With the pressing need to making the most of available resources, a way has been found for utilizing these and other low-grade ores. The NML made a country-wide study on the amenability of low-grade manganese ores to beneficiation. Ore samples from Andhra, Bombay, Madhya Pradesh, Mysore, Orissa and Rajasthan were investigated. The findings are that the majority of these ores can be upgraded to a manganese content of 48 per cent and above and can be utilized for ferro-manganese production. The complexity of these investigations can be well apreciated when it is realized that no two ores are alike and that each has to be tested separately to determine its beneficiation characteristics for upgrading it to the required *specifications.* Industrial pilot plant tests for manganese ore beneficiation have been carried out. The NML also advised a number of State Governments and commercial enterprises in putting up large-sized plants.

In the mining of iron ores for smelting purpose, the utilization of the ore



The desliming, conditioning and flotation unit of the Integrated Mineral Beneficiation Pilot Plant It has the capacity to treat up to five tons of ore per hour.

has become more complicated because of the Indian weather conditions. The matter was simple when hand mining was used as selective mining yielded lump-size iron ore material. With the introduction of heavily mechanized mining, due to the expansion of the iron and steel industry, separation of ore fines by the manual method cannot be attempted or accomplished. It has been experienced at the steel plants that under Indian weather conditions, the screening and handling system becomes completely blinded and choked due to the muddy conditions caused by the tropical rain in the admixture of iron ore fines with the lumpy materials. It is thus of paramount importance to separate the fines from he lumpy iron ore materials, both in fair and rainy weather, and to utilize the iron ore fines thus separated to the maximum national advantages. The high alumina content of the ore also affects the smelting operation in the blast furnace. The problems of improving the quality of ores despatched from the mines and also of ensuring regular supplies of properly blended and sized ores to steel plants for the production of quality sinter were successfully tackled at NML. Based on the investigations conducted at NML, the steel plants in the public and private sectors are putting up their ore beneficiation and sintering plants.

For limestone to be used as a metallurgical flux, the maximum availability of the base (CaO) is essential, and for that purpose the silica content of the limestone should be low so that its CaO content is not used up in fluxing its own silica in the steel-making furnace. The percentage of silica in limestone for use in open-hearth steel-making should therefore contain a very low silica content, preferably of the order of 1-2 per cent. The quality of the Indian limestone used in steel-making vis-a-vis its silica content is deteriorating, and with these poor grades of limestone, production in the steel plants is adversely affected. It is therefore very essential to beneficiate the limestone so as to reduce its silica content. Comprehensive work on upgrading of limestone for steel-making was successfully undertaken on a pilot-plant scale. The use of upgraded limestone in steel-making promises considerable potential as shown by the full-scale steel plant trials conducted in the country's steel plants.

Smelting of Iron Ore in Low Shaft Furnace

The distribution of suitable mineral deposits imposes limitations on the ultimate pattern of heavy industry throughout the country. This will be apparent from the fact that the distribution of basic raw materials like iron ore, and particularly metallurgical coal, is rather confined to selected areas in the north-eastern region; this has led to the concentration of the iron and steel industry in this region. In keeping with the policy of the Government of India to promote a regional distribution of basic industries, alternative methods of iron production, utilizing non-coking fuel for reduction purposes, are being investigated by the National Metallurgical Laboratory in its 15-ton/day Low Shaft Furnace Pilot Plant. Smelting trials conducted so far have shown that foundry-grade pig iron can be successfully produced using the low-

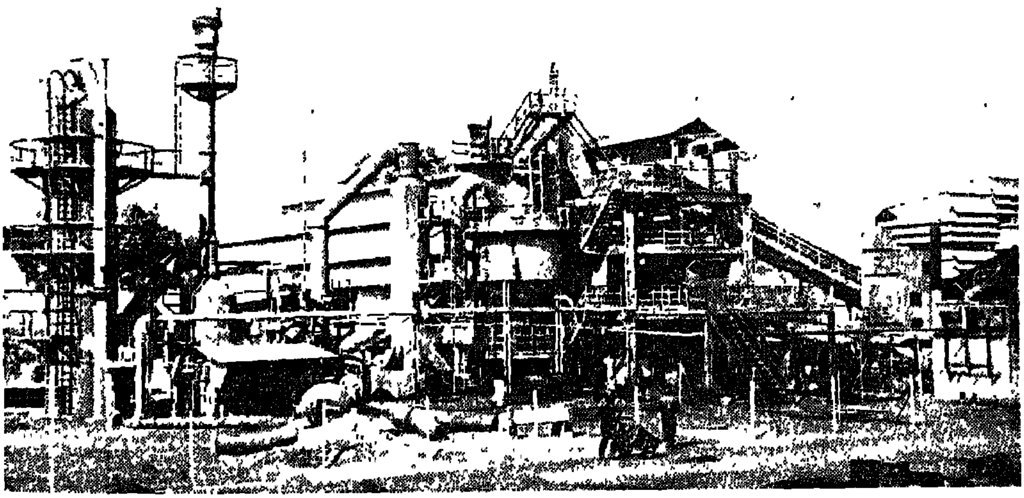
shaft furnace smelting technique. On behalf of the State Governments of Andhra Pradesh, Punjab, Maharashtra and Rajasthan, pilot plant investigations have been completed at the Pilot Low-Shaft Furnace, determining the suitabilities of the regional raw materials for the production of foundry grades of pig iron. On the basis of Investigation Project Reports prepared by the NML, based on these comprehensive Pilot Plant trials, the establishment of industrial plants for the production of foundry-grades of pig iron is now well on its way in suitable locations.

Ferro Alloys

With the establishment of alloy, tool and special steel plants in the Third Five Year Plan, there will be a great demand for different types of ferro-alloys. In India, at present there is no commercial-scale production of ferro-alloys, excepting ferro-manganese and ferro-silicon. The Laboratory has developed techniques for manufacturing important ferro-alloys, such as low-carbon ferro-chrome, carbon free ferro-chrome, ferro-vanadium, ferro-titanium, ferro-tungsten, nitrided ferro-alloys, etc., from indigenous materials which have been produced on a tonnage scale and supplied to ordnance factories to meet their requirement.

Non-Ferrous Metals

Magnesium, which is indispensable in the production of light alloys for aircraft and is used in metallic form for



A panoramic view of the Pilot Low Shaft Furnace Plant of 15-ton/day capacity, installed at the National Metallurgical Laboratory.

strategic military requirements, has been produced successfully for the first time in India on a laboratory scale in the National Metallurgical Laboratory. The present requirement of this metal is met by import. The National Metallurgical Laboratory is putting up a pilot plant to produce magnesium metal as well as magnesium powder to meet the requirement of the ordnance factories. The plant will be put into commission in the near future. The Laboratory has also developed the technique of producing electrolytic manganese metal and manganese dioxide from low-grade manganese ore containing as little as 15 per cent manganese. Electrolytic manganese metal is of vital importance for producing special steels such as stainless steels, high-speed and tool steels, and other ferrous and non-ferrous alloys, which are to be made in the near future in the country. This metal and its dioxide will be produced on a commercial scale in the near future, utilizing the NML process.

Foundry Moulding Materials

To meet the needs of the fast-growing foundry industry, a long-term project is in progress on the assessment of the moulding characteristics of various Indian foundry sands and bonding materials. A large number of foundry sands and bonding clays have been investigated and the data obtained have been made available to foundries in the country. In the past, no organized attempt was made to collect data for the foundry sands in use. Now methods have been developed to improve certain difficult sands by processes such as washing and grading to yield material suitable for use as moulding sands. Advice has been given to foundries on melting procedures, types of furnaces and fluxes to be used, and methods of obviating gas absorption. To help the small foundries, National Metallurgical Laboratory has established regional foundry stations at Batala, Howrah, Madras and Bombay.

Corrosion of Metals and Alloys

The National Metallurgical Laboratory is also fully alive to the need for metallurgical researches on the corrosion of metals and alloys and has already done extensive work on the causes and effects of corrosion phenomena. It is assisting metallurgical industries in defining their corrosion problems, and suggesting remedial measures, etc. Long range research work on the corrosion of metals and alloys under various atmospheric conditions is under way and interesting results have been obtained in certain cases. The National Metallurgical Laboratory has set up a corrosion research station on the sea-coast at Digha, in West Bengal, to study the various aspects of corrosion under marine atmosphere.

Refractories

With the steel ingot production reaching higher targets, as formulated under the successive Five Year Plans, there will be a corresponding rise in the demand for refractories which form the backbone of the iron and steel as well as metallurgical, glass, ceramic, cement and brick kiln industries. Refractories are used as lining materials for industrial furnaces and other high-temperature operations. It has been estimated that a one-million ton

steel plant requires about 150,000 tons of refractories during its installation and about 80,000 tons for annual replacement. The chief feature of the development work at the NML is the production of new types of basic and special refractories from the abundantly occurring but little utilized minerals. The Laboratory has already developed techniques of manufacture for a number of special and basic refractories which are now in commercial production.

For small-scale melting of brass, special alloy steels, non-ferrous alloys and precious metals, India imports carbon- and clay-bonded graphite crucibles. Techniques for preparing carbon- and clay-bonded graphite crucibles from indigenous raw materials have now been developed at NML. A number of firms have been given licence for manufacturing carbon- and clay-bonded graphite crucibles by this process.

Pilot Plants

The role of pilot plants in metallurgical research and development is today undisputed. Whilst the fountain-head of metallurgical research are the basic concepts of the fundamental sciences, it is through pilot-plant trials and investigations that the success or failure of a paricular research theme is determined—whether a particular process will eventually be adopted on an industrial scale or will fall by the wayside on the hazardous road between development and industrial production. The factors in pilot-plant trials range from the basic chemistry of metals to financial evaluation of metallurgical processes in terms of their ultimate economics. Following the well-known maxim 'Commit your blunders in a small way and earn your profits in a big way', the role of pilot plants in metallurgical research and development attains great importance. Such a role assumes still greater importance in India, which has embarked on heavy industrialization through successive Five Year Plans. The gulf between metallurgical research on the one hand and industrial implementation of research on the other is wide anywhere, and particularly so in India. The urgency and importance of pilot-plant investigations have been fully established and increasing emphasis is being laid on pilot-plant investigations of processes developed at the National Metallurgical Laboratory. The fields thus enlarged relate to:

1. Low Shaft Furnace Pilot Plant
2. Pilot Plant for the Production of Ferro-alloys in the Submerged Arc Electric Smelting Furnace from indigenous ores
3. Pilot Plant for Beneficiation of Low-grade Ores and Minerals
4. Pilot Plant for Thermal Beneficiation of Low-grade Manganese and Chrome Ores
5. Pilot Plant for Hot-dip Aluminizing of Steel Wires and Strips
6. Pilot Plant for the Production of Vanadium Pentoxide from Vanadiferous Magnetite Ores
7. Pilot Plant for the Production of Special and Basic Refractories from Indigenous Raw Materials
8. Pilot Plant for the Production of Electrolytic Managanese Metal and Manganese Dioxide

9. [illegible] Method and Oxygen Injection in Side Blown Basic Converter and L. D. Converter
10. Iron Production in Vertical Shaft Furnace by Fuel Injection
11. Pilot Plant for Production of Magnesium Metal and Magnesium Powder
12. Pilot Plant for the Production of Synthetic Cryolite.

In February 1963, an integrated Mineral Beneficiation Pilot Plant was commissioned which is one of the largest anywhere. This Pilot Plant has a capacity of treating up to 5 tons of ore per hour. Since its commissioning, it is yielding exceedingly useful results of potential value to mineral and metal industries, which have in recent years been increasingly appreciative and ready to accept the immediate value and long term benefits of research and development work in their economic pattern of exploitation of the indigenous mineral wealth of our country.

Fundamental Problems

Although emphasis has been laid on operational and applied research projects, the Laboratory has pursued with equal vigour fundamental projects which have resulted in the advancement of knowledge in the field concerned, besides training a corps of research workers. The fundamental problems under investigation relate to isothermal transformation studies on Indian plain carbon and alloy steels, solubility of nitrogen in plain carbon alloy steels, carbon activity in iron and its alloys, studies on age-hardening, interaction between solute and solvent atoms in the liquid state, studies on temper brittleness, phase studies on electro-deposited copper-tin alloys, studies on phase transformation in alloys by the X-ray diffraction technique, morphology of phosphorus in Indian manganese ores, studies on the properties of rare earths etc.

Patents

The Laboratory has so far been granted forty four patents in India and abroad. Most of these patented processes have been taken up by industries on premia and royalty basis for commercial exploitation, and five patents have been released entirely free of royalty and premia under instructions of the CSIR, chiefly for the benefit of the small-scale industries.

Processes Ready for Commercial Exploitation

As a result of intensive research and pilot plant work done at the National Metallurgical Laboratory, twenty-four new techniques and processes were made ready for commercial exploitation. Of these twenty-four processes, the following twenty-one have already been leased out on royalty and premia basis to industries for use in commercial production. These also include five processes which were released free of royalty and premia for the benefit of small-scale industries.

1. An improved process for electrolytic production of high purity manganese dioxide.
2. An improved method for the production of manganese salts from manganese ores, and its application for the regeneration of the spent electrolytic manganese sulphate baths.
3. An improved process for the production of electrolytic manga-

nese metal.

4 Hot-dip aluminizing of ferrous materials.
5. Improvements in or relating to magnesium silicate refractories and use of the same.
6 A process for making completely stabilized dolomite refractories.
7. Refractory compositions comprising graphite and silicon carbide. (Carbon-bonded graphite crucibles)
8. Refractory compositions comprising graphite and alumino-silicate materials and glazes to render such compositions resistant to oxidation (Clay-bonded graphite crucibles.)
9 *Refractory compositions* containing non-refractory chrome ore and refractory products made therefrom
10. Preparation of liquid gold.
11. Electroplating of metals on aluminium or its alloys.
12. Chemical polishing of aluminium.
13. Metallization of non-conductors
14. Brass-plating from non-cyanide bath.
15. Production of dense carbon aggregate suitable for being used as base material for carbon products in general and Soderberg paste in particular.
16 Production of electrical-resistance alloys for heating elements.
17. The technology of the production of thermostatic bi-metals.
18. Production of Alnico type permanent magnets.
19. Production of chemically bonded metal clad or unclad basic refractory.
20. Production of iron powder for autogenous cutting
21. Production of carbon-free ferro-alloys by aluminothermic reactions.

Symposia

Conferences and symposia on subjects of direct industrial interest in the present planned economy offer valuable media for the exchange of technical data and growth of research themes and original ideas. Proceedings of conferences and symposia are also very important for the benefit of those who do not directly participate but are concerned with the utilization of research results and operational data. For this purpose, proceedings of the symposia held so far have been brought out with the least possible delay. So far, the National Metallurgical Laboratory has organized symposia on the following subjects:

	Subject	Year
1	Electroplating and Metal Finishing	1952
2.	Industrial Failure of Engineering Metals and Alloys	1953
3.	The Non-ferrous Metal Industry in India	1954
4.	Recent Trends in the Field of Production, Practice, and Research on Refractories used in Metal Industries	1955
5.	The Production, Properties and Application of Alloy and Special Steels	1956
6.	Mineral Beneficiation and Extractive Metallurgical Techniques	1957
7	Recent Developments in Foundry Technology	1958
8	The Iron and Steel Industry in India	1959
9.	The Pilot Plant in Metallurgical Research and Developments	1960
10	The Light Metal Industry in India	1961
11.	The Ferro Alloy Industry in India	1962
12	Recent Developments in Iron and Steel Making with Special Reference to Indian Conditions	1963
13.	Utilization of Metallurgical Wastes	1964

Industrial Liaison and Technical Aid to Industries

As metallurgical industries are becoming increasingly conscious of the application of research results, nume-

rous technical problems are being referred to the Laboratory in ever increasing measure, these are being effectively handled to mutual satisfaction consistent with quality. Technical liaison is also effectively maintained with the industry through publications brought out by this Laboratory, such as the *NML Technical Journal*, proceedings of the symposia, monographs embodying the results of long term projects, preliminary project reports, Investigation Project Reports and Special Reports, periodical press releases on some of the major achievements, popular brochures and bulletins on the processes developed by the laboratory for commercial exploitation of patented processes, collection and dissemination of statistical data through international symposia on metallurgical subjects and last but not least through field investigations by the technical staff of the Laboratory at the request of the industries themselves and also at the initiative of the Laboratory.

The National Metallurgical Laboratory is acting as a nucleus for many of the long range and short-term projects connected with the development of the metal and mineral industries, which are being referred to in increasing numbers by the National Mineral Development Corporation, Railway Design and Standards Organization, Hindustan Steel and other establishments both public and private sectors. Long range fundamental work has also been done for making the best use of foundry raw materials and to evolve national standards.

The National Metallurgical Laboratory has specific roles to play in promoting basic and fundamental research in metallurgical subjects, and more so in undertaking applied research and pilot plant industrial-scale trials for the development of the mineral, and ferrous and non-ferrous metal industries in the country. As such, the research and development themes at the National Metallurgical Laboratorry are aligned to the industrial growth in mineral and metal fields projected during the successive Five Year Plans; these requirements place a high premium on ingenuity in metallurgical research and development so that it is accepted as an asset for the industrial potential of the country. In this planned yet dynamic growth of the Indian mineral and metal industries, the active role of the National Metallurgical Laboratory has today not only been fully established but is also adequately appreciated in an ever-increasing measure. The progress in these fields at the National Metallurgical Laboratory has been significant, steady and rewarding. It may be mentioned that out of twenty-four new techniques and processes which were developed for commercial exploitation as a result of intense research and pilot plant work, twenty-one have already been leased out to industries for use in commercial production. Reviews of the research and development work at the National Metallurgical Laboratory appearing from time to time in the international technical press at home and abroad, have given the young Laboratory a "deservedly high reputation in the metallurgical world". And yet far more remains to be accomplished under the rising tempo of our Five Year Plans, to which end the young National Metallurgical Laboratory is fully dedicated.

Classroom Experiments

Experiments in Biology for Class VI

Experiment to find out which part of the root grows most

Soak some pea or gram seeds in water and let them germinate. When the root has grown about ¼ of an inch or so, make some equidistant marks on the root with Indian ink, starting from the tip onwards Take two rectangular glass pieces of equal size. Place a pad of blotting-paper on one of the glass pieces. Now place the marked seeds on the blotting-paper and cover it with the other glass piece. Tie the two together with the help of rubber bands. Place the arrangement, as shown in Figure 1, in a beaker containing water so that the level of water may touch the blotting-paper. By doing this the seed will get a continuous supply of water. After two or three days observe the change. You will find that the division behind the tip of the root has become longer. Thus more growth takes place in this zone.

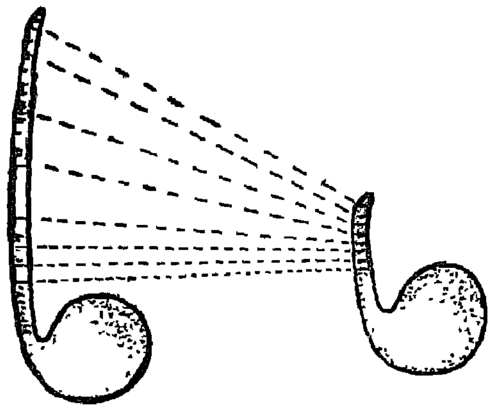


Fig. 1 Experiment to show the zone of elongation.

Experiment to show that light is necessary for the formation of starch in leaves

Take a potted plant which has already been kept overnight in the dark so that all the stored starch in the leaves may be translocated to the stem. Take two pieces of black paper, from the centre of one of which the letter 'S' has been cut; clip these pieces of black paper on a leaf, one on the upper side

and the other on the lower side. Now keep the leaf in sunlight. After a few hours, pluck this leaf and test it for starch. To test for the starch extract the chlorophyll from the leaf by boiling it first in water and then in warm alcohol heated in a water bath. After the leaf is bleached, wash it with water in a petri dish and pour a few drops of iodine solution on it. Observe the change in colour. You will see that the part covered with black paper remains unchanged, whereas the exposed part, i.e., the 'S' turns blue. (Figure 2.)

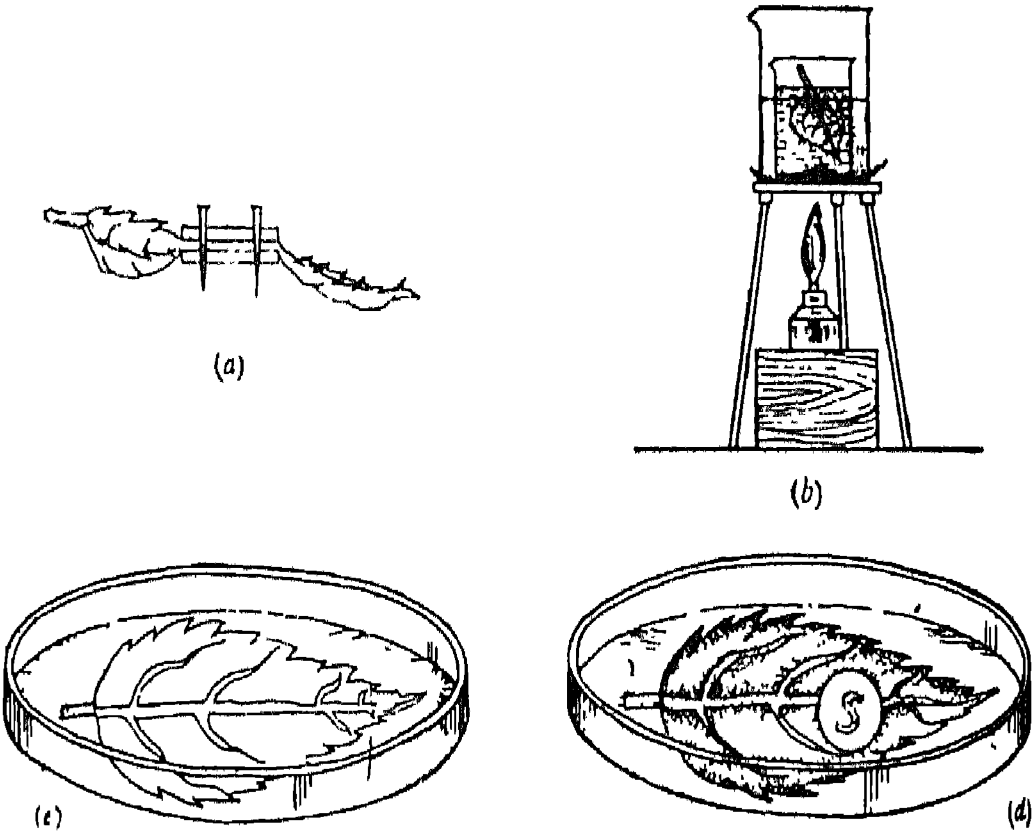


Fig. 2. Stages in the experiment to demonstrate the formation of starch in the green leaf in the presence of light.

Science Abroad

Some Thoughts on Science Education for the Developing Countries of Africa

G. S. PURI

MAN is the noblest of all creation and comes at the end of evolution. He is bestowed with mind, body and spirit, and is capable of reasoning, logic, concentration, meditation, change and improvement.

In his relation with the universe, however, man has come to a stage where he possesses the means of destroying his own habitat, along with all other forms of life, including himself. He also has the means for evolving into a superior type of being, for making the earth a paradise and changing the entire picture of the universe. Whichever direction the human species will evolve into, would depend upon the type of education the future citizen will receive. In the material world human progress is based essentially on education in science and technology. Science today is intimately related with world affairs. In view of the murderous forces now at man's disposal, it is difficult to discuss science as detached in any way from politics. Pugwash conferences are series of "discussions that are directly and vitally concerned with the safety of mankind for all times." Every year scientists from all parts of the world meet and discuss ways and means of relaxing present tensions in the world. The 1964 conference at Karlovy Vary considered collective security problems, the ending of colonialism, the effect of disarmament on science and technology, international cooperation, etc. It was considered that "in the long run, a peaceful world will require the solution of such issues as racial inequalities and economic disparites between nations and peoples".

This paper is the outcome of the Pugwash theme and an attempt is made here to integrate science and religion in a system of education. The developing region of Africa has many intriguing problems and it is hoped that its educational development programme will greatly benefit by the presence in Africa of many renowned scientists of the world. The author humbly invites criticism of the points put forth in this paper with the hope that a sound system of education of African youth will be developed in line with Pugwash thought.

The different types of emphasis given to culture, science and religion make the discussion of educational planning a difficult one, especially when econo-

mic development and politics are dependent on science and technology, and culture, as it is known today, is related to history, anthropology, sociology and religion. Development involves the change of a rural environment to a highly industrialized one with artificial conditions. In the process several indigenous values will have to be rejected and many others, exotic to the present African environment, will have to be assimilated. All this can be done only through a properly balanced education.

Educational Philosophy through the Ages

Education, meaning leading out (Latin), is the process that shapes the potentialities of the maturing organism by informal or formal means. Informal education is the individual's reaction to the environment and the consequential formation of habits and character to survive adverse influences. Formal education consists in the conscious efforts of society to impart skills and modes of thought considered essential for the individual's well-being.

The Socratian view that the highly trained mind turns to virtue predominates till today in educational philosophy. It is for this reason that all great religions have taken a conspicuous part in education through the ages. In ancient Greece, Homer was symbolic of freedom, and education included music, mathematics and gymnastics so as to train both body and mind. The classical system of education still largely leans on mathematics for training the human mind.

Seventeenth-century education aimed at the development of the individual for social living. In the early twentieth century, education laid emphasis upon experimentation to meet the demands of the changing environment. Till a few years ago, science and technology were considered to be the most important part of universal education, with little or no place for religion or the humanities in the educational curriculum of scientists.

There are in the main four types of thought dominating the thinking of man today: (1) The Marxians' efforts for a classless society and international communism, (2) The militant revival and the use of force to attain a global order; (3) The use of nuclear power for peaceful purposes and for creating a wealthy, materialistic society, and (4) The application of science and technology to obtain the best from the social order.

Most of the contemporary thinkers, including such world authorities as Fenelon, Oscar Wilde, George Eliot, Nicholas, Berdyaev and Lucretius, are against the exploitation of man by man through religion. Lucretius is supposed to have said: "Religion is a disease born of fear and is the source of untold misery to the human race." Unfortunately, however, all the four main bodies of thought are up against religion which is still undoubtedly the greatest single power working on the mind of man. Is religion really detrimental to human progress and prosperity?

According to Sankara's system of Vedantic philosophy, man is dignified and divine, and God and man are consubstantial. It is not the doctrine of religion that is at fault but the people who interpret it with ulterior motives in a basically exploitive and parasitic

system of society. It appears, therefore, that there is a need for a return to the medieval world order to some extent for the incorporation of religion into the education of man. Men in the East, like Gandhi, Tagore and Aurobindo, have felt the need for a renaissance and have made efforts to interpret politics, economics, history and science through religion and philosophy. Bertrand Russell has added his powerful plea for a world restoration of order and abolition of war as a means for achieving peace. Many Pugwash scientists are exploring avenues for bringing in a peaceful world. The U.N. charter recognized 20 years ago the need for the development of friendly relations between man and man and the promotion of economic and solid progress for all. This itself is the true essence of all religious teachings, and brings to mind again the need for a true integration of science and religion for the common good of the human family.

The Concept of the Educational Equipment of Man

In the changing world society, with nationalistic aspirations and international humanistic ideals, there is a great conflict today between science and religion. In spite of all its beneficial aspects, science has, however, not been able to win universally the heart of those who regard materialistic prosperity as not being an end in itself. To the man of religion, who dominates thinking very largely in the developing regions of the world today, material prosperity does not seem to be the only means of human happiness and progress. The ancient civilizations of India and China had attached little importance to only material progress. They laid greater stress on human values and on understanding man's urge for the preservation of peace and welfare for all mankind

There is a great deal to be said against this type of spiritual existence, since it created the climate for man to live a half life in starvation, illiteracy and misery. Nevertheless, the urge for spiritual well-being, interpreted and practised correctly, is a live force and would remain so for all times in the world of science

There is no doubt that scientific advancement has eased the life of man and has provided him with tools that have lessened the agony of labour and drudgery. Nevertheless, science has not conquered anger or the other baser elements in man's character, and with highly developed technology man has got the capacity to destroy at will everything which is so important for his well-being. If science was able to conquer fear, it would have probably received a more universal appreciation than religion, or at least an equal appreciation; but instead it has created in the mind of man today a universal fear of wholesale destruction.

Science is concerned with the cosmic and biological habitats of man. Religion on the other hand, works in the psychological domain, in which the known methods of scientific enquiry do not apply. Religion lays the stress on personal experience, whereas science deals with objective experimentation. Since the three habitats—cosmic, biological and psychic—of man are interrelated and represent different stages in his evolutionary development, it is desira-

[illegible] of the [illegible] and [illegible] should [illegible] the [illegible] aspect of human behaviour in the world of science and of religion. This can be done only if a new educational system is evolved which should provide knowledge of both the Finite as well as of the Infinite and treat problems not at national but at world level.

One of the greatest world problems today is hunger. Recent estimates have shown that 1,500 million people are malnourished and half-fed, and are only half alive. This is partly due to overpopulation. In over half a million years the human population has reached 3,000 millions, but in the next 35 years it is going to be doubled. Increased output of food can help, but only if human societies that are psychologically still prisoners of their past are ready to learn the new techniques of science.

B. R. Sen, Director General of FAO, while discussing the importance of considering development in ecological terms, stressed that in the developing regions of Africa and Asia, where 60 to 85 per cent of people are engaged in agriculture, "it is agriculture that has to produce leverage for economic growth". Priorities should be given to revolutionizing backward agricultural practices. He stressed that the entire educational system of developing countries should be reorientated towards development. Illiteracy is a barrier against the flow of knowledge and creates isolation and engulfs man with traditional and inefficient social values and practices. Religion is still a powerful influence and it must be coordinated [illegible] in the education of youth. Religious teachings combine the knowledge of the Finite and the Infinite into a complete whole.

1. *Knowledge of the Finite*

All the phenomena which are described as seen and unseen, through human perception, come under the category 'Finite'. The Finite could be divided into three main components:

(a) *Cosmology.* This includes studies of the cosmos, universe, earth, stars, sun, moon and other heavenly bodies; their numbers, size, distances and movements. Man is busy exploring the cosmos and his attempt to reach the moon and some planets of the solar system seems to be capable of realization well within his life span. Technological skill has provided photographs and other data of heavenly bodies, thereby enriching man's knowledge of the cosmos.

It is still not known definitely whether the universe is flat, open and endless, based on Euclid's plane geometry or whether it follows Einstein's conception of curved space, due to the gravitational pull of the stars, galaxies and interstellar gases. It is also thought in some circles that the universe is bent on itself. Recently 3C-9, a new quasi-stellar source, has been seen to be moving away from the earth at 149,046 miles per second. The light spectra of this and several other sources seem to support the theory of a Finite Universe, born with a bang, 13 billion years ago. According to this theory, matter alternately explodes and expands, falls back together, and then explodes again, and so on, in a cycle recurring every 82 billion years. It

appears that science will soon be able to solve this one of the greatest mysteries of our times.

b. *The Earth.* The existence of life has not been proved on other parts of the cosmos. So far the earth is the only planet known to be fit for the life of man and other animals and plants. The source of all energy on the earth is the sun The movement of this planet in space and in time, and the force of gravity, are some of the important questions that education must clearly bring to the mind of the young student at a very early stage of his understanding. There are two things in the universe: matter and energy. The study of matter should be done through physiography, geography, geology, magnetism, erosion, sedimentation, volcanism, etc. The transformation of matter into energy in the form of heat, light, electricity, etc., has to be stressed in teaching the properties and uses of matter. In the modern educational programme, one should also stress the physical, chemical and biological conceptions of matter, and the conversion and uses of energy.

c. *Biome.* Plants, animals, and man are the biotic part of the universe. They are dependent upon the inorganic part of the universe the interrelationship of the inorganic and organic parts through ecological studies in the ecosystem has to be stressed rather than only their independent studies. The ecosystem development and channelling of energy and its conservation for the prepetuation of the systems are linked up with the production of energy.

Since man is a part of the ecosystem, his physical, biophysical, biochemical and physiological behaviour with respect to laws of growth, health, physique, reproduction and survival must be studied in relationship to both the biotic and the abiotic parts of the environment, taking into consideration also the forces of heredity and gravity. It must be realized that life on the earth today has a past and a future Man should, therefore, be considered a part of the dynamic phenomena. Although the human species seems to be the end of biological evolution, it is certainly not the dead end, therefore, the role of man in his own evolution has to be clearly stressed so that study of biological material may also be allied to religion. The phenomena of ageing and its relationship with sanitation and preventive, curative and promotive medicine—both in animals and in man—is to be given prominence in such studies.

The education of man is designed for the good of man, it is therefore, imperative to include in our educational programme such questions as the origin of man, generical differences between the races, migration, and settlement and urbanization of human communities in response to changes in the environment. Culture, art, politics, social and economic behaviour, and welfare and peace are important studies for the material well-being of the human species. The biological necessities of food and nutrition are important in the physical and physiological sense. In biological study, the idea of universal brotherhood and world government, and of men having equal opportunities is to be brought into the curriculum of any educational programme.

[illegible] of the Infinite

It is said that man does not live by bread alone, and ever since the human species [illegible] developed an urge for getting at the ultimate truth. The object was to obtain peace and immortality. In some parts of the world, this spiritual urge of man has greatly influenced the relation of the human species with other organisms. We have evidence to show that at least for the last five thousand years, man has striven, often successfully, to realize the Infinite. These strivings of man are manifested in the four major religions: Hinduism, Buddhism, Christianity and Islam. Although all the religions have the common goal of realizing the Infinite, the methodology and approach have been different due to local differences in the environment. These sometimes led to conflicts between men practising different religions. Nearly all of these religions, however, advocate meditation or *nama*, which does not find favour in this age of scientific and technological development. There are several other areas in which religion and science have come in conflict against each other. Not only this, the different religions themselves have in the past expressed a great deal of dissatisfaction with one another. There have been periods of open conflict and war. Religion is part of politics, and even in a democracy religious minorities find the most uncongenial conditions for cultural and economic growth. There is often persecution on religious grounds. It is, therefore, very necessary that the citizens of the future be given training in comparative religions and in the humanities, so that future civilizations can live peacefully and peaceful coexistence. This is possible only if science and religion develop a mutual understanding and help in the solution of world problems, avoiding sectarian or regional policies.

The Ecosystem Concept and Unity in World Thought

Along with the knowledge of the physical, biological and spiritual relationship of man with both the abiotic and biotic parts of the environment, it seems logical to emphasize the unity of all the factors involved. This synthesis can be best achieved under the ecosystem concept. Religion and science have come to some sort of understanding in two major political systems, namely, capitalism and socialism. At the present moment, the world seems to be divided between these two ideologies, and it is, therefore, very important that in any educational programme an objective and scientific study of both these systems be made. These are the governing processes in the development of the whole ecosystem of man, as they determine the physical, biological, psychological and spiritual relationship of all organisms. The concept of making a paradise on the earth and helping in the creation of universal brotherhood of man can only be emphasized through the ecosystem concept in the educational programme.

This type of educational programme is certainly new and it involves the study of the sciences, humanities, religion and philosophy in a comprehensive curriculum. It is realized that there will be innumerable difficulties in designing such a programme but it is nevertheless extremely important that